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THE INFLUENCE OF TWO COMPETITIVE SEASONS OF ICE HOCKEY ON NINE YEAR OLD BOYS

BY

© STEPHEN D. GILL

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance a thesis entitled: "The Influence of Two Seasons of Ice Hockey on Nine Year Old Boys", submitted by Stephen D. Gill in partial fulfilment of the requirements for the degree of Master of Science in Physical Education.

ABSTRACT

The purpose of this study was to observe and monitor the relative changes in functional fitness levels of pre-adolescent hockey players compared to non-hockey players over the period of two years; December 1973 to April 1975. Two groups of nine year old boys from Malmo Community, Edmonton, participated in the study. The experimental group consisted of fourteen boys who played organized competitive hockey and the control group consisted of eleven boys who did not play organized hockey. The tests which were administered included anthropometric measures, static measures of grip strength, the CAHPER Fitness-Performance Test Items and the PWC_{170} test on a bicycle ergometer. These tests were conducted at the completion of the 1973-74 and 1974-75 hockey seasons. In addition, the hockey group was given a battery of hockey skill tests, both pre and post season, for the two years in question.

Both groups improved their respective mean scores on the height, weight, bi-iliac and bi-acromial measures over the period of two years. It was observed, that for the hockey group, the mean values of all these variables were consistently greater over this time period than those of their counterparts. However, the mean differences between the groups did not appear to be as great in the second year as in the first. The grip strength results also showed this trend. Although the hockey group demonstrated greater mean values in both years of the study, the difference was less in the second year than the first. In the case of the CAHPER Fitness-Performance Items, both groups appeared to improve their respective group mean scores on each sub-test item with one exception, the shuttle run. The hockey group mean scores were consistently better than those of the control group. The results of the Physical Work Capacity 170

test showed that while the hockey group was superior in both PWC_{170} and PWC_{170} per kg. body weight in the first year, the control group was superior in year two.

Over the duration of two years, the experimental group completed the hockey skill tests on four separate occasions. Their performance on these items continued to improve from one session to the next. The most dramatic improvements occurred in the backward linear skate (90') and the Modified Marcotte puck control and Hansen agility skate tests.

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INTRODUCTION

The focal point of research designed to ascertain measures and evaluate functional physical fitness parameters, particularly endurance fitness, of children appears to be aimed at establishing norms for normal, healthy post-adolescents. Many studies conducted on normal children relate physical working capacity to sex and age (2, 3, 4, 5, 6, 8, 9, 14, 25, 29, 30, 38, 39). Another popular orientation appears to be literature related to the measurement and evaluation of maximal oxygen consumption and cardiac output of normal children (6, 7, 8, 15, 16, 18, 19, 23, 28, 32, 38). These studies assist in providing a foundation of guideline information. Certain studies have also had as their objective the measure and evaluation of specific training programs on highly trained adolescent athletes. Cumming (17) and Daniels (19) both reported on the effect or influence of specific training programs administered to adolescent athletes over the duration of a prescribed period of time. The domain of functional fitness research appears to be specifically oriented towards normal children in their adolescence years. Very few studies have investigated the fitness levels of elementary school-aged children (8, 9, 26, 33, 37, 38) and to the author's knowledge there are no studies, except Thibault (39), which report the effect of training or participation of pre-adolescent children in organized sports programs, particularly organized and competitive hockey.

This study is a continuation of a longitudinal investigation designed to determine the influence of participation of pre-adolescent males in organized competitive hockey. Thibault (39) conducted the

inaugural investigation in 1973-74. He employed an experimental group and control group, each consisting of fourteen, eight year old boys from Malmo Community, Edmonton. The experimental group participated in an extensive season of ice hockey; approximately fifty games in the period of four months and the control group did not participate in organized hockey competition. Thibault (39) reported pre and post season mean values for the following parameters: age, height, weight, anthropometric measures, grip strength, CAHPER Fitness-Performance Items, physical work capacity (PWC_{170}), and a battery of ice hockey skill tests. Statistical analyses were conducted to determine the differences between means and inter-group mean differences. The present investigation is the second in a continuing series of studies. The experimental group has remained as described and the control suffered a decline in enrollment. All the subjects are a year older and more familiar with the testing procedures. The format of the present investigation included the computation and analysis of post season values for the same parameters, with the exception that pre and post season mean values are also listed for the hockey skill tests. The test regime that was employed over the past two seasons is listed in Table I. Thus, this study was organized to monitor and report the differences, if any, between post season 1974 mean data and post season 1975 data; over the duration of two consecutive hockey seasons. Also, any differences between pre and post season 1973-74 and 1974-75 mean values on the hockey skill items will be reported. Throughout the body of this report, mean values on all the parameters will be compared and contrasted to national norms for males of the same age.

Statement of the Problem

The measurement and assessment of a variety of functional physical fitness parameters was the focal point of the present investigation. Two groups of 9 year old boys; one group of 14 hockey players who participated in an organized competitive hockey league over the duration of four months and a control group consisting of 11 non-hockey players, were employed as representative subjects to determine the influence of a competitive season of ice hockey on various functional physical fitness parameters.

Specifically, the study focused on the following physical fitness parameters:

1. Anthropometric measures:
    - body height and weight
    - bi-acromial measures
    - bi-iliac measures
2. Grip strength measurements:
    - left and right hand grip strength
3. Functional physical fitness as determined by:

    (a) C.A.H.P.E.R. Fitness Performance Items
    - 50 yard dash
    - 300 yard run
    - shuttle run
    - standing broad jump
    - flexed arm hang
    - one minute speed sit-ups

4. Physical work capacity test (PWC_{170})
   - Sjostrand modified bicycle ergometer test as described by Howell and Macnab (25).

Limitations of the Study

It is necessary to acknowledge the following limitations of this study:

1. The study was limited by the lack of available research material pertaining specifically to the influence of training on pre-adolescents.
2. Another possible limitation of this study was the test mortality rate; the attrition that occurred as a result of personal reasons.
3. The limitation of maintaining control of the subject's physical activity patterns.

Delimitations of the Study

It is necessary to acknowledge the following delimitations of the study:

1. The study was delimited to a selected community in Edmonton, Alberta, called Malmo Community.
2. The study was delimited to nine year old male subjects.
3. The study was delimited to one major competitive sports activity; ice hockey.

Definition of Terms

Kilopond: One kp. is the force acting on a mass of one kilogram at the normal acceleration of gravity.

Kilopond meter: is the physical work unit done on a bicycle

ergometer during a specific period of time. It is the product of the tension in kiloponds applied against the bicycle wheel, and the distance covered by the wheel during one complete revolution of the pedals multiplied by the number of revolutions per minute. It is expressed in kilopond meters per minute, kpm, min.

Work load: refers to work performed against a fixed resistance and measured in kpm, min.

Physical Work Capacity (PWC_{170}): the ability of an individual to perform prolonged physical work at a steady state, submaximal heart rate of 170 beats per minute on a stationary bicycle ergometer.

Functional Physical Fitness: For the purpose of this study functional physical fitness refers to physical powers and endurance of the individual.

Experimental Group: refers to that group of subjects, consisting of 14 individuals, who participated and competed in an organized season of competitive hockey.

Control Group: refers to that group of subjects, consisting of 11 individuals, who participated in physical activities other than hockey.

REVIEW OF LITERATURE

Grip Strength

The literature, related to the measurement and evaluation of grip strength, appears to pursue two modes of investigations. One avenue appears to be concerned with the progression of grip strength improvement concurrent with increasing age and the second route categorizes factors that influence grip strength. A vast majority of these reports are aimed at the age groups of puberty and post-puberty, the years of life that are characterized by the greatest strength development. These single measure studies served to provide descriptive and normative classifications. A limited amount of research is devoted to ascertaining the influence of training on the grip strength of young males.

Espenschade (21) and Hunsicker (27), conducted investigations designed to observe the strength gains concommitant with increasing age, particularly from early years to age twenty. Espenschade reported that there was a characteristic improvement in strength from birth to a peak in the early twenties. He noted that there was a rapid increment in grip strength of approximately 65 percent for both boys and girls between the ages of 3 and 6 years. Hunsicker reported that only one-fifth of a person's total peak strength was acquired by the age of 6 years.

Bookwalter, et al., (10) analyzed male grip strength in an attempt to show its relationship to age and weight. With regards to age, they reported that left hand strength tends to increase generally, however, showed more irregularity in progression and varied variability than right hand grip. Also, left hand mean grip strengths are less

than mean right grip strengths for every age group. The mean difference at regular increments ranged from 5 to 14 pounds. Generally, both left and right grip strengths increased with an increment in weight. The right mean grip strength of males in relation to weight was from 3 - 13 pounds greater than léft hand mean grip strength for every weight group.

Besides analyzing male grip strength in relation to two anthropometric parameters, these results also established grip strength norms for males ranging in age from 9 through 24 years.

Howell, Lorsoille and Lucas (26) conducted an extensive investigation in 1966 designed to determine grip strength measurements of Edmonton school children. They employed a method of selecting a random sample of both public and separate school children which was suggested by the Dominion Bureau of Statistics (Edmonton). Consequently, a random sample of five elementary, five junior high schools and five senior high schools were selected. The sample size consisted of 39 females and 36 males at each age level from 7 through to 15 years of age. A reserve sample of 5 subjects per age and sex group were also drawn. A Smedley Adjustable Grip Dynamometer was the instrument selected to measure grip strength. Three trials with each hand was permitted and the average recorded as the individual's score. All measures are recorded in pounds. The mean right and left grip strength values recorded for nine year old males are 37.7 and 36.3 pounds respectively. The strength measures recorded in this investigation served to establish provincial norms for Alberta school children.

Montpetit <u>et al</u>. (36) reported the grip strength measurements of four hundred and eighty-five boys and four hundred and twenty-three

girls ranging in age from 8 years through to 17 years. Grip strength was measured using a Collin (elliptical) dynamometer. In a standing position, each subject was allowed two trials, alternating right to left, to squeeze the dynamometer with a maximal effort. Mean grip strength values of the dominant hand are recorded. The mean right grip strength value recorded for nine year old boys was 15.6 kgs. or 34.3 pounds.

Frazer and Cook (22) conducted an investigation designed to determine the effect of various sporting activities on grip strength development. The sample consisted of 37 male candidates from the Edmonton Public School system. They ranged in age from 8 to 11 years. The subjects are divided into groups according to their sporting preference. Group I consisted of 14 boys, mean age 9.8 years, who are members of the Malmo Community Mite A hockey team. (This group of boys are the experimental group in the present study.) Group II consisted of 9 members of the University of Alberta Gymnastic Club ("Bounders") whose mean age was 9.3 years. Group III was composed of 14 subjects, mean age of 9.3 years, each characterized by no participation in organized athletic programs. (This group is the control group in the present study.) Grip strength was tested using a Smedley Adjustable Grip Dynamometer. In a standing position, each subject was allowed one trial to maximally squeeze the dynamometer. Individual and group mean strength values are recorded in kilograms. The mean right and left grip strength values for the hockey group, 26.5 and 24.2 kgs. respectively, are the highest values recorded. The control group mean values for right (24.6 kgs.) and left (22.3 kgs.) are second highest. The mean right (23.2 kgs.) and left (21.6 kgs.)

grip strength values are the lowest of the three groups examined. Frazer and Cook concluded that it was difficult to determine which of the two factors; growth or training, had the most predominant influence.

Thibault (39) measured the grip strength response of two groups of 8 year old boys on two occasions; four months apart. One group consisted of 14 boys who participated in an organized hockey league and the other group consisted of 14 non-hockey players. The tests were conducted at pre and post hockey season. A Smedley Adjustable Grip Dynamometer was the instrument used to measure grip strength. In the standing position, each subject was permitted two trials with each hand and the best score achieved was retained. It was reported that the mean right and left grip strength values for the hockey group were consistently higher than the means for the control group. Both groups showed a substantially great improvement for the left hand over the four month period. Thibault concluded that statistical analysis revealed no training influence for the strength measures and that significant pre-post season increases for both groups are attributable for the most part to normal growth.

The results of the aforementioned studies clearly indicated that the extent or influence of training on the grip strength performance of young males is undetermined. For the most part, increments in pre-adolescent grip strength are basically attributable to normal growth.

<u>CAHPER Test - Performance Items</u>

The Canadian Association for Health, Physical Education and Recreation (CAHPER) organized a standard fitness performance test

designed to establish fitness norms for Canadian boys and girls ranging in age from 7 to 17 years. The performance test included six easily administered subtests involving basic motor skills. The subtests consisted of speed sit-ups, standing broad jump, shuttle run, flexed arm hang, 50 yard dash and a 300 yard run. Details of the subtests are presented in Appendix I. A sample of 500 boys and 500 girls were randomly selected from elementary and secondary schools across Canada. The test results established percentiles, means, and standard deviations for each sex and age. These are presented in the CAHPER Test Manual (12).

Cummings and Keynes (18) conducted a survey of the fitness levels of Winnipeg school children in the spring of 1965. The sample consisted of 497 normal elementary and secondary school children ranging in age from 6 to 18 years. Two complete classes of each grade from one through twelve were selected to participate in the test regime. Eight physical educators supervised the administration of the tests over the duration of one week. The test battery included all the subtests listed in the CAHPER Test Manual (12). The mean test scores for a sample of 41 male nine year old boys are as follows: the mean number of speed sit-ups recorded in one minute was 29, the mean distance achieved in the standing broad jump test was 52 inches, the mean for the arm hang was 27 seconds, the mean number of seconds to complete the shuttle run, the 50 yard dash and the 300 yard run are respectively 12.0, 8.9, and 76 seconds.

Thibault (39) administered the CAHPER Fitness - Performance Items on two occasions to a sample of 28 boys, eight years of age from Malmo Community in Edmonton. The subjects are divided into

equal groups, 14 boys in each group. One group consisted of hockey players who participated in an organized competitive hockey league, and the other group consisted of non-hockey players. The tests were administered, as described in the CAHPER Test Manual (12) to both groups prior to the hockey season and again four months later at seasons end. Means and standard deviations are reported for both groups. Thibault reported that there appeared to be no significant improvement for both groups between pre and post season means for the 50 yard dash, 300 yard run, and the standing broad jump. For the remainder of the sub-tests, he reported that the hockey group means improved more significantly than the control group means. Thus, the hockey group improved more substantially on the agility test and those requiring arm and abdominal strength.

The CAHPER Fitness - Performance Items incorporate a wide variety of motor skills. It would appear from the studies reported that there is no conclusive evidence to suggest that highly trained pre-adolescents have a definite advantage over normal children. However, these tests afford an individual the opportunity to make cross-sectional comparisons; with others of the same age and sex.

Hockey Skill Tests

The advent of hockey skill tests designed to measure and evaluate basic fundamental skills and manoeuvers is a relatively new concept. Previous research investigations have had as their subject matter more difficult and complex motor patterns and skills. This new approach has as its focal point the idea of providing teachers and/or coaches with an objective means of evaluating different ability levels and recognizing strengths and weaknesses between players.

Merrifield and Walford (34) developed and experimented with a battery of ice hockey skill tests designed to measure specific basic skills in ice hockey. A sample of 15 male Ithica College students, ranging from non-experienced to experienced players, participated in the tests. A test battery, including such skills as forward and backward speed skating, agility skating, puck control skate, passing and shooting was administered twice over the period of one week. Each subject was permitted two trials and the best score was recorded to the nearest one-tenth of a second. Test reliability and validity scores are the only results available. The reliability coefficients ranged from 0.74 to 0.94 on the skating items. The validity coefficients for each of the four skating tests, when compared to subjective rankings in each skill, ranged from 0.75 to 0.96. The puck carry test correlated highly with the other three tests and was determined as the best single overall determinant of one's hockey ability.

The foundation of the battery of hockey skill items employed in the present study was originally designed and validated for Hockey Canada by H. Hansen, G. Moore and Wm. Maloney in 1970. Hansen (24) has since revised and modified the original battery to include puck control, agility skate, forward and backward linear speed skate (see Appendix J for a complete description of these tests). A diagnostic or ranking scale was employed to compare and contrast the timed scores achieved. Hansen administered this battery of hockey skill performance items to several hundred boys enrolled in the Ottawa Municipal Hockey School over the duration of two years. The subjects ranged in ages from 7 through 16 years. All groups received instruction and demonstration twice a week for ten weeks except the 7 to 9 year olds who received

instruction for five weeks. The tests are administered to all groups at two month intervals. A panel of experts was used to measure and record data.

Hansen related two sets of scores according to age group categories. These recorded scores are listed as expected times to be achieved and pre and post season test values. The mean "expected times" for the 8 - 9 year old category are 5.5 and 10.8 seconds respectively for the 90' forward and backward linear speed skate, 14.1 seconds for the agility skate and 23.5 seconds for the modified Marcotte puck control test. The actual pre and post season mean times for boys 8 - 9.5 years of age (97 - 114 months) are listed as follows:

	Pre	Post
Agility	15.5	14.1
Puck control (Mod. Marcotte)	24.3	23.2
Forward skate (90')	5.6	5.7
Backward skate (90')	10.7	9.8

All mean scores appeared to improve except the 90' linear skate, which remained virtually the same. The test results furnished the participants and organizers with intrinsic evidence of the value of such a screening and measuring device. They also provided norms for each age group.

Hockey skill tests of the nature previously described are an asset to coaches and teachers in establishing objective criteria and prerequisites to screen potential hockey players. They also offer students of the game a goal to strive for and achieve.

Physical Work Capacity

The measurement and assessment of functional fitness of children is usually viewed in two dimensions; functional fitness of normal,

healthy children and secondly of unhealthy children. The scope of this literature is aimed primarily at exemplifying the functional differences between these two groups. The literature devoted to normal children deals with school children aged 12 through 18 years, adolescent to post-adolescent years. A limited amount of literature is devoted to pre-adolescents and in particular the effect or influence of a regimented training program on various fitness parameters.

Howell and Macnab (25) conducted an extensive nation-wide cross-sectional survey in 1967 to measure and assess the physical working capacity of normal Canadian school aged children. They investigated a random sample of two thousand, one hundred and seven male and female children from the age of 7 to 17 years. Because of the complexity and awkwardness of direct techniques of measuring maximal oxygen intake, they employed an indirect method of measuring physical work capacity. The authors employed and adapted the Sjostrand test which measures physical work capacity concurrent with a steady state heart rate of 170 beats per minute. The test involved pedalling a stationary modified bicycle ergometer (Monarch) for a maximum of twelve minutes, four minutes at each of three progressively more intense work loads. The heart rate of the subjects was monitored by an electrocardiogram at the end of each minute of exercise. The heart rate at the end of the fourth minute of each work load was plotted against the particular work load and a regression line was drawn and extrapolated to a heart rate of 170 beats per minute. The data was analyzed to provide age and sex differences in PWC 170 and PWC/kg. body weight. A continuous increase in mean PWC 170 for each age group from 7 - 17 was observed in the male sample. The mean results of the female sample

revealed an increment to age 13 and a continuous decrease from this point. The males are superior to the females throughout the entire age range. At nine years of age the mean PWC 170 value for the males was 384.7 kpm. compared to 306.4 kpm. for the females. When expressed in terms of body weight, the mean values for the males remained steady throughout the entire age range whereas the mean values for the females declined, especially after age 12 years. At age nine the mean PWC 170/ kg. body weight value was 12.73 compared to 10.27 for the female sample at the same age.

These results served to produce in concrete terms Physical Work Capacity norms for Canadian school children.

Cumming, G.R. and Cumming, P.M. (14) conducted a single session test regime to measure the response of heart rate to known amounts of generalized work of 200 Winnipeg school children. The sample, including males and females, ranged in age from 6 to 16 years. All subjects pedalled an electronically braked bicycle ergometer (Holgrem and Mattson) for a maximum of 18 minutes at a rate of 60 - 70 rpms. per minute. The work intensity was increased at 6 and 12 minutes of exercise. The heart rate at the end of the 6th and 12th minute of each work load was plotted against the particular work load and a regression line was drawn and extrapolated to a heart rate of 170 beats per minute. The data was analyzed to provide age and sex differences in PWC 170 and PWC 170/kg. The results revealed that there was a gradual increment in mean PWC 170 values with increasing age, for the male subjects and the mean PWC 170 values increased to age eleven for females, and appeared to continuously decline thereafter. The mean working capacity values for the boys was consistently greater than that of the girls throughout

the entire age range. At the age of 9, the male sample mean PWC 170 value was 435 kpm. and mean PWC 170/kg. body weight was 12.79.

Adams et al. (4) evaluated the cardiac response to exercise of 243 normal white school children of Los Angeles, California. All subjects, male and female, ranging from 6 to 16 years, are randomly selected. Prior to the actual testing, each subject was screened according to their medical status. The method employed for determining physical working capacity was that of Sjostrand and Wahlund. Each subject performed three consecutive work load trials on an electronically braked ergometer. The pedalling rate was maintained between 60 - 70 rpm. and each work load trial lasted six minutes. The heart rate was determined both with a stethoscope and an electrocardiogram taken every second minute during each six minute trial. Work loads were scheduled to produce desired heart rate responses. Working capacity was calculated on graph paper by plotting the heart rate against the work load and a regression line was drawn. In general, the values for the various factors (height, weight, surface area, blood pressure, vital capacity and working capacity) increased with age and the boys are generally superior to the females. Differences in mean PWC 170 values, between sexes were observed at the earlier ages and became more pronounced at later ages. Of the factors investigated, physical working capacity was found to correlate best with surface area. The mean PWC 170 value for nine year old males was 472 kpm/min. or when expressed in terms of body weight the mean value was 13.45.

In a subsequent study, Adams et al. (3) investigated the physical working capacity of two groups of normal male and female Swedish school children, ages 10, 11, and 12 years. One group numbering 102 was from

a Stockholm city school and the other group, numbering 94, was from two country schools. To determine the influence of the summer holidays on the working capacity, a group of 22 boys and 25 girls from the city school are retested at the beginning of school in September. The method used for determining the working capacity was that of Sjostrand. Each subject performed two consecutive 6-minute work load trials on an electrically braked ergometer at 60-70 rpms. Heart rate was monitored every two minutes on an electrocardiogram. The working capacity was determined by means of a regression line and extrapolation. As expected, each of the various factors increased with age and the mean values for boys are greater than the mean values for the girls. The physical working capacity mean values for the 10 year old male and female normal city school children are 490 and 420 kpm/min. respectively. Expressed in terms of body weight, these mean values are 13.61 kg. for the male group and 12.72 kgs. for the female group. On the other hand, the mean PWC 170 values for the male and female normal country school children of the same age are 510 and 374 kpm/min. respectively. Translated in terms of body weight, these mean values are 15.45 and 10.00 respectively. Although the mean PWC 170 values recorded for the country children were greater according to sex and age, the difference between means was not considered to be significant as there was no significant difference in the slopes of the regression lines.

Macek, J., et al. (30) conducted a single test regimes to investigate the physical working capacity of two groups of children from Prague with the intent of comparing these results to previously obtained and reported international mean values. The first group

consisted of 63 healthy boys and girls aged 8, 10, 12, and 14 years. The other group of Prague children consisted of 45 boys and 45 girls, 12 years of age and 45 boys and 40 girls, 14 years of age. The test format was different for the respective groups. The subjects in the former group were examined using a hode-hyperbolic Ergometer "Lannooy" Model Standard, in three subsequent days with only one submaximal load per day for the duration of 5 minutes each day. The work load was 1 Watt per kg body weight, 2 Watts per kg body weight and 2.5 Watts per kg body weight in the first, second and third days respectively. The working capacity was determined by means of extrapolation. The latter group performed three consecutive work load intensities - 1 Watt, 2 Watts, and 2.5 Watts per kg body weight, each of 6 minutes duration with a rest interval of 1 minute in between. Anthropometric mean data [height (cm) and weight (kg)] and W 170 mean values for each age and sex category are listed in tabular form and also compared to values obtained in children groups from several countries (Sweden, California, Canada, etc.). W 170 and W 170/kg. body weight mean values are reported in Watts (1 Watt = 6.1 kpm/min.).

The mean W 170 values reported for the Prague children indicated an increment for both sexes concurrent with increasing age, and that the mean W 170 values for the males are consistently greater than the female values. The mean W 170 value for 8 year old males was 62 Watts (378 kpm/min.) compared to a mean W 170 value of 59 Watts (359 kpm/min.) for the females of the same age. Expressed in terms of body weight these values are 14.00 and 9.20 kg respectively. The mean W 170 values for the 10 year old male and female groups are 74 Watts (451 kpm/min.) and 72 Watts (439 kpm/min.) respectively. The mean W 170 values, when

expressed in terms of body weight, remained virtually the same for both sexes in each age category. However, it was apparent that the male mean values were consistently greater than the females.

By inspection of the W 170 mean values, it appeared that the Canadian contingent scored the lowest (70 Watts - 427 kpm/min.) and the California group mean score was the highest (90 Watts or 549 kpm/min.). The authors concluded and recommended that the evaluation of the relevancy of W 170 for physical fitness was difficult until such time that more standardization of methods and procedures are exercised.

Andersen, K.L., et al. (6), conducted an investigation to provide "base line information" or normative data on physiological exercise parameters during growth. Normal school children at the ages of 8, 10, 12, 14, and 16 years of age were selected from a rural Norwegian inland community named Lome. The sample included 83 boys and 88 girls. Physical work capacity was determined by exposing the subjects to increasing work loads on a bicycle ergometer of the mechanical braking type. Two submaximal loads, of the duration of 6 minutes each at 60-70 rpm. were performed to produce about 30-50% and 55-80% of maximal aerobic power. Heart rate and the number of pedal revolutions are monitored continuously throughout the duration of each test. With regards to height and weight, mean values for each age and sex category, it was observed that the mean height values remained virtually the same at each age for both groups, however, the mean weight values for each age category were consistently higher for the females, with the exception of the 8 and 16 year olds. Body weight mean values, when expressed in terms of lean body mass (L.B.M.) and percent body fat, are consistently better for the males in each age category. The male mean

PWC 170 values increased continuously at each age category; the mean value increased from 392 kpm/min. at 8 years to 464 kpm/min. at 10 years of age. Female mean PWC 170 values also increased at each age level, but not to the same extent as their male counterparts, especially after the age of 12 years. The mean PWC 170 are consistently and significantly greater for the males at each age category.

From the material examined in the previously cited studies (3, 4, 6, 14, 25, 30, 31), a number of conclusions appear to be apparent. When expressed in absolute terms with regards to age, particularly between the ages of 7 and 18 years, maximum working capacity values appear to improve. Also, a distinct trend is apparent. The mean working capacity values appear to improve continuously throughout the entire age range for males. On the other hand, the mean working capacity values for females appear to increase to approximately the age of 13 years at which point a conspicuous 'levelling off' of values occur. All authors concluded that the mean working capacity values for the male segment were consistently greater than those for their female counterparts throughout the entire age range.

Further general conclusions are obvious when physical capacity was expressed in relative terms; PWC 170/kg. body weight. Aerobic work capacity was generally agreed to be virtually the same for both sexes up to the age of puberty. To this point in the growth process, sex differences in work capacity appeared to be negligable. However, at puberty, girls' fitness becomes lower and diverges from the boys'. Expressing the work capacity data as PWC 170/kg. body weight reveals a rather steady value for males throughout the entire age range and a decline for the females.

A number of postulations have been presented to elucidate this trend, of which two explanations appear most frequent. Adams (3, 4), Andersen (6), Macek (30), and Howell and Macnab (25) indicated that sex differences and the decline in females' aerobic capacity can be derived and attributed to hormonal differences at puberty, which result in conspicuous differences in body composition. Females develop a higher ratio of adipose muscle tissue during the fertile period contrasted by an increase in muscular strength in males due to the furthering effect of the male hormone. Adam (3) and Macek (30) also postulated that these sex differences may represent a "cultural phenomenon". Andersen (6) presented a further and more elaborate explanation with regards to the sex differences. He related that "the variability coefficient for maximal oxygen uptake becomes reduced when expressing the data on the basis of body weight and even more when the data are on the normalized basis of fat-free body weight, since fat tissue does not contribute to the evaluation of metabolism during work". Thus sex differences appear to disappear when MVO_2 is related to fat-free body weight.

The previous section dealt primarily with normative and descriptive literature that was derived from single measurements. These results served to establish in concrete terms, standards of physical work capacity for normal children ranging in age from 8 to 18 years.

Adams, et al. (3) re-evaluated the physical working capacity of 47 Stockholm school children to determine the influence of summer vacation on this parameter. They observed that a total of 19 girls and 16 boys (N=35), 77.7% of the original group registered no change or only a slight improvement over the duration of four months. It

was also observed that the latter scoes of all these subjects was below the mean PWC 170 score for their respective age groups recorded in the initial test session.

Alderman, R. (5) reported the results of a longitudinal investigation designed to measure the physical working capacity of normal male and female school children aged 10 and 14 years over the duration of one year. Of secondary interest was the consideration of the distinction between regarding changes as related to age and regarding them as a function of age. The subjects were randomly selected from an Edmonton urban school population. The former sample (10 year olds) consisted of 58 subjects, 29 boys and 29 girls; and the latter sample (12 year olds) consisted of 41 subjects, 19 boys and 22 girls. The subjects did not participate in any particular regimented training program. Each subject pedalled a constant work load bicycle ergometer (Elema-Schonander) according to the method of Sjostrand; 4 minutes against three different work loads. Heart rate was continuously monitored by means of a Sanborn 500 Viso-Cardiette. The same test was repeated a year later. Physical work capacity was calculated according to the line of best fit (linear regression) and extrapolation. The initial and repeated mean PWC 170 results and standard deviations are reported for each group according to age and sex. The results of the initial test session indicated that age differences within sexes and sex differences within age levels in PWC 170 are generally what one would expect. The mean PWC 170 value for 14 year old boys was 797.6 kpm/min. compared to 317.0 kpm/min. for the 10 year old boys. The 14 year old female group mean PWC 170 score was 487.1 kpm/min. in contrast to 287.4 kpm/min. reported for the 10 year old girls. The

males are generally superior to the females within the same age category, with one exception, the mean PWC 170 score for 10 year old males was not significantly different than the mean value for their female counterpart. All groups improved their respective PWC 170 mean scores to a statistically significant degree over the duration of one year. The mean PWC 170 score for 10 year old males improved by a difference of 252.9 kpm/min., compared to an improvement of 135.2 kpm/min. for the 10 year group of females. In general, the improvement was greatest for the males, especially in the younger age bracket.

Cumming and Danzinger (15) performed a repeated measures test regime, over the duration of five months (May - September) to observe changes in physical working capacity of normal Winnipeg school children aged 10 and 11 years. At the outset of the investigation a sample of 49 grade five students volunteered to participate in the program, of which 41 subjects (19 boys and 22 girls) were re-examined in September. All subjects were exercised on an electronically braked bicycle ergometer for two successive 6 minute work periods at 60-70 rpms. Cardiac response to exercise was continuously monitored by an electrocardiogram. The work load at an anticipated minute pulse rate of 170 beats was determined by extrapolation. Of the 19 male subjects retested, only 7 showed an increase in PWC 170, the remaining 12 subjects showed no change or a decrease in physical working capacity. The same trend was apparent for the females, only 10 subjects showed an improvement, the remainder showed no change or a decrease in score. With regards to the respective group mean PWC 170 scores, both groups failed to show a significant increase. The mean PWC 170 score for the boys decreased an average of 15 kpm/min. (411 - 396) over the duration of 5 months and

the mean PWC 170 score for the girls increased from 336 to 348 kpm/min. over the same time period. The authors concluded that in the absence of a determined effort at physical training, normal summer activity was insufficient to improve PWC 170 in normal children.

Baggley, G., and Cumming, G.R. (9) studied the seasonal variations of endurance measures; physical working capacity and maximal oxygen consumption, of elementary and high school students from Winnipeg during a school year (September through to June). The subjects included an entire elementary school class (16 boys and 14 girls), ranging in age from 9 to 12 years; and a grade 10 high school class of 17 boys and 16 girls, ranging in age from 14-17 years. The mean age in September of these groups was 11 and 16 years respectively. The former group completed the exercise test five times and the latter group three times over the one year period. The exercise test included pedalling a mechanically calibrated electronic bicycle ergometer at 60 rpms, continuously for two steady state 6 minute submaximal work loads and one supermaximal work load for the duration of 3 minutes. Physical working capacity values are determined by intrapolation from the two submaximal work loads. Expired air was collected during the third minute of the supermaximal work regime in weather balloons and analyzed for oxygen with a calibrated paramagnetic oxygen analyzer and for CO_2 with soda lime. The significance of any changes observed in these parameters was assessed with paired date 't' tests. Expressed in absolute terms, the mean PWC 170 scores for the elementary school boys increased progressively over the year from 569 kpm/min. in September to 641 kpm/min. in June. The absolute mean PWC 170 scores for the girls of the same group improved from 412 to 441 kpm/min. over the same period.

However, the improvement was not significantly different at the .05 level. When expressed in terms of body weight, the relative mean PWC 170 scores for both males and females remained virtually the same. The mean range for the male subjects was 15.8 to 16.4 kg/body weight, and 9.6 to 10.3 kg/body weight for the females.

The mean VO_2 max. for the elementary boys increased significantly from September to December, both in absolute values (1.66 to 1.88 litres per minute) and relative to body weight (45.1 to 49.2 ml/kg/min.). The absolute and relative mean MVO_2 values for the elementary females failed to show any significant improvement.

In regards to sex differences for the elementary group, it was concluded by the authors that the significant difference between males and females was attributed for the most part to differences in lean body mass.

The data for high school boys showed a decline in both mean PWC 170 and MVO_2 values, however, the change was so small that it did not reach significance. Mean PWC 170 and MVO_2 values remained constant for the high school girls throughout the year. Differences in muscle mass was attributed for the significant differences in male and female mean PWC 170 and MVO_2 scores.

In general the results indicated that both working and aerobic capacities of these Winnipeg school children remained fairly constant over the duration of a school year.

These studies represent measurements of a longitudinal nature, repeated measures of the same subjects over a period of time of school children's fitness levels through examination of physical working capacities and maximal oxygen consumption (Baggley and Cummings). The

data and results of these investigations provide virtually the same conclusions, that the daily living and activity patterns of normal children are not sufficient to perpetrate any significant improvement in working and/or aerobic capacities. However, these studies offered evidence to substantiate the expectation that age and sex differences exist. There was no mention of the influence of specific training programs in any of these studies.

Thibault, G. (39) conducted a longitudinal investigation to determine the influence of a competitive season of hockey on the functional physical fitness level of eight year old boys. The participants included 28 boys from Malmo Community in Edmonton, S.W. One half of these subjects are registered in the "Little Richard Hockey League". This group participated in a strenuous, competitive season of hockey which included 50 scheduled and exhibition games and 20 practices. The remaining portion of the sample included 14 normal boys who did not participate in an organized hockey league. This group served as the control group. The twenty-eight subjects completed a series of tests conducted at pre and post hockey season. The initial test regime was performed in December and the latter in April; a duration of 4 months. The battery of tests included a PWC 170 on a modified bicycle ergometer as described by Howell and Macnab (25), the CAHPER Fitness - Performance Items and four static strength measures on the modified Heltinger Chair (for children). In addition to these tests, the 14 members of the hockey group completed a batter of hockey skills tests as outlined and described by Hansen (24).

With regards to the anthropometric measures, the results appeared to indicate that over the duration of four months the hockey group showed

a more rapid improvement or rate of growth than the control group. At the outset of the investigation, the mean PWC 170 value for the control group was 394 kpm/min. and 391 kpm/min. for the hockey group. The respective mean PWC 170 values at the termination were 409 kpm/min. and 433 kpm/min. The hockey group appeared to improve by an average of 42 kpm/min (10.5%), compared to an average improvement of 15 kpm/min. (3.8%) recorded for the control group. When the PWC 170 values were expressed in terms of body weight, the experimental group mean values improved significantly more than the same for the control group. With regard to the CAHPER Fitness - Performance Items, the difference in pre and post season mean results appeared to indicate that the control group improved more than the experimental difference, however, the experimental group mean values are better overall. The experimental group improved their mean left and right grip strength values significantly more over the period of four months. Generally, a significant improvement in the hockey skill tests was observed. The only exception was the pre and post season mean values recorded for the 60 and 120 foot backward skating distances.

In conclusion, Thibault claimed that the effect of training was most pronounced in the parameter of physical work capacity.

Cumming, G.R. et al. (17) measured various physiological responses of young male and female athletes, ranging in age from 12 through to 18 years who participated in an intense one week track and field training camp. Among the variables investigated, aerobic capacity and maximal oxygen consumption were stressed. The physical working capacity and maximal oxygen consumption of 14 boys and 15 girls were measured on an electronically braked bicycle ergometer (Elma) at

60-70 rpm. All subjects completed the tests on day 1 and day 6 of the camp. Mean VO_2 max and PWC 170 values are recorded and compared using paired data 't' tests. The male group mean PWC 170 value increased from 960 kpm/min. on day 1 to 1082 kpm/min. on day 6. This average improvement of 122 kpm/min. over the duration of six days was significant at the .001 level ($p < .001$). The mean PWC 170 value for the female group improved from 720 kpm/min. to 795 kpm/min. over the same period. This increase was not considered significant. With regards to VO_2 max. no significant changes were observed for either group. A slight increase in mean values from 3.92 to 4.02 l/min was recorded for the boys and the mean MVO_2 value for the group of females varied from 2.76 to 2.75 l/min. The authors related the improvement in mean PWC 170 values for both groups to a decline in submaximal work pulse rates over the week of training. In general, Cumming and his cohorts concluded that factors influencing VO_2 max. such as heart and stroke volumes and lung capacity are not likely to be modified with a week of intensive training in already 'fit' subjects, hence no significant changes were observed in VO_2 max.

Daniels, J. and Oldridge, N. (19) performed an investigation designed to measure the changes in max VO_2 at a submaximal running speed of growing boys engaged in regular running training. The selected sample consisted of 14 Albany Wisconsin school boys ranging in age from 10 to 15 years. Running was choosen by these boys as an extra-curricular activity. The subjects participated in a submaximal and maximal treadmill running test at the start of the program and approximately every six months thereafter for the duration of 22 months. A total of 6 boys completed the maximum of five test sessions,

and data was collected on all 14 subjects during most test sessions and in every case over a full year. Anthropometric data, including age, weight and height, and Ve and VO_2 data was recorded at each session. Expired gas was collected in meteorological balloons and analyzed for CO_2 and O_2 content with a Lloyd-Gallenkamp volumetric analyzer. Over the 22 month period there was an average increase in mean height of 11.2 cm, and increase in mean weight of 9.2 kilograms. A significant increase in MVO_2, 2331 to 2839 ml/min. was observed. When expressed in terms of body weight, the mean values decline from 59.5 to 58.3 ml/kg/min. over the period of 22 months. This change was considered insignificant. However, there was a significant improvement in efficiency as indicated by a decrease in VO_2/kg at submaximal running from a mean value of 52.0 at the outset to 45.5 ml/kg/min. at the duration of 22 months.

Massicotte and Macnab (33) conducted an investigation to determine the relative effects of three different training intensities on children. Thirty-six boys, between the ages of 11 and 13, from the same school in Edmonton, Alberta, volunteered to participate in this six week training study. Prior to the training program, each subject completed a maximal oxygen uptake test according to the method of Astrand and modified by Macnab. Each subject was ranked and categorized according to their respective relative VO_2 max. scores and then randomly assigned to either of the four treatment groups. Each treatment group (N=9), trained on a Monarch bicycle ergometer, three times per week, each session lasting 12 minutes, at a work load sufficient to elicit heart rates of 170-180, 150-160, 130-140 beats per minute for treatment groups T_1, T_2, and T_3 respectively. Group T_4

acted as the control group. The subjects in each treatment group commenced training at different work loads depending on their initial physical working capacity. Pre and post training mean values for heart rate, VO_2, V_E, lactate oxygen pulse and respiratory quotients are recorded. The results indicated that all the training groups significantly improved their maximal work loads and their respective submaximal heart rates over the duration of the six week training regime. The highest intensity training group (T_3) also showed a significant improvement in VO_2 max. with training. This was further substantiated by significant alterations in their blood lactate levels. Following training, significant changes in submaximal and maximal work load lactate levels are recorded. No significant changes were recorded for either of the treatment groups on the remaining parameters that were investigated. Massicotte and Macnab (33) concluded that for short training sessions, the training threshold necessary to elicit improvement of aerobic capacity in 11 to 13 year old children should be above 170 beats per minute.

The previously cited appear to indicate that training primarily affects submaximal and maximal pulse rates. With regards to MVO_2, the authors tend to agree that two very essential criteria must be met in order to achieve a training effect, especially for pre-adolescent children. These two variables are the intensity of the training session and secondly the duration. Massicotte and Macnab (33) suggested that in order to improve the aerobic capacity of children, the training heart rate should be above 170 beats per minute or approximately 75% of the difference between the resting and maximal heart rates. Saltin commented on the duration of training in the article by Massicotte and

Macnab (33). He differentiated between the effects of endurance training over the period of a short and long duration. Saltin related that the short-term changes are best illustrated by a better distribution of cardiac output; a more complete extraction of oxygenated blood in the working muscle while long-term changes were best exemplified by an increase in the stroke volume.

METHODS AND PROCEDURES

Sample

A sample of twenty-five pre-adolescent normal males, aged 9 years (as of December 31, 1974) was selected from Malmo Community and Michener Park in Edmonton. These subjects were selected and categorized according to their status as hockey players. The hockey or experimental group consisted of 14 subjects, all of whom played on the Malmo Community Mite 'A' representative hockey team. They played approximately sixty games, including league, tournament and exhibition games over the period of four months, December through March. As well, each player was encouraged to skate as frequently as possible, other than weekly practice sessions. Over the summer months the majority of these boys enrolled in hockey schools and/or power skating classes. The control group was composed of 11 boys, aged 9 years, who were non-hockey players; they did not pursue organized hockey competition as a past-time sport. However, these boys were athletically inclined by their own nature. Three of the subjects participated in a low-keyed community hockey league and the remainder engaged in various other sports activities such as community basketball and floor hockey. All subjects participated in a similar study a year previously conducted by Thibault (39). Retesting of the subjects in the present study showed no attrition in the hockey group, however, the control group sample was reduced in number. Three subjects excused themselves from the program due to personal reasons. Time did not permit substitution.

Testing Conditions

Pre and post season hockey skill tests were conducted at the University of Alberta Ice Arena. The former test was completed on

October 4, 1974, and the latter on February 23, 1975. Ice and temperature conditions were the same for both test sessions. This was in contrast to the testing conditions a year previously as the hockey skill tests were conducted and completed on an outdoor ice surface. Both ice and temperature conditions varied markedly.

The remainder of the test regime, including the CAHPER Fitness - Performance Items, the grip strength test, and PWC 170 was completed at post season, the first week of April 1975. The grip strength and PWC 170 tests were conducted at the Malmo Community Centre and the CAHPER test battery was performed and completed at the University of Alberta.

The testing regime that was employed over the duration of two consecutive hockey seasons is listed in Table I. Thibault (39) conducted pre and post season tests on all the parameters. Statistical analyses were completed to observe the differences between means over the period of four months and also inter-group differences. In the pre-season of 1974, hockey skill tests were performed by the experimental group. Post season tests were conducted on all the parameters for both groups in 1975.

Testing Procedures

Parents and test participants were contacted and consulted prior to the outset of testing. The author's intentions were announced and explained at the time. With the exception of three control group members, the parents and the remaining twenty-five subjects consented to participated in the program. Before each test session in the spring, all parents were contacted to confirm test appointments.

TABLE I

Testing Regime

(Two Consecutive Hockey Seasons)

Parameters	1973-74 Pre Season	1973-74 Post Season	1974-75 Pre Season	1974-75 Post Season
Age	x	x		x
Weight	x	x		x
Height	x	x		x
Bi-iliac	x	x		x
Bi-acromial	x	x		x
Grip Strength	x	x		x
CAHPER Fitness - Performance	x	x		x
PWC 170	x	x		x
Hockey Skill Tests	x	x	x	x

Hockey Skill Tests

Hockey skill tests were conducted according to the procedure of Hansen (24). A description of the test procedures accompanied by diagramatic representations are presented in Appendix J. The test courses were constructed prior to the subjects arrival at the arena. Instructions to warm-up were given prior to the actual testing. An explanation and demonstration accompanied each test. Mistrials were repeated at the end of the group. The time required to complete each course for all subjects was recorded to the nearest one-tenth of a second.

The balance of the test regime was completed by both groups at post season, April 1975. Each subject completed the following tests.

Anthropometric Measures

Height and weight were recorded using a Decto-Medic scale. Each subject was measured wearing gym attire; shoes and shorts. Bi-iliac and bi-acromial measures were taken with a millimetric 'L-shaped' ruler. Measurements are recorded to the nearest one-tenth of a centimetre.

Strength Measurements

Right and left grip strength measures were conducted using a Smedley Adjustable Grip Dynamometer. Measurements are recorded in kilograms. Two trials with each hand was allotted and the best score was recorded. An explanation and demonstration preceded each test. The 'inner-stirrup' was adjusted accordingly for each subject. Each subject was instructed to position the dynamometer at arms length above the shoulder and "squeeze" the inner stirrup as hard as possible while lowering the dynamometer to a position at arms length to the side of the body. It was emphasized that at no time was any part of the body to be

utilized as a level system. After squeezing maximally with one hand the subject was instructed to repeat the procedure using the opposite hand. Verbal encouragement was expressed during each test.

CAHPER Fitness - Performance Test

This battery of motor skill tests was conducted in the main gymnasium at the University of Alberta. The format described in the CAHPER Test Manual (12) was employed. The test descriptions are presented in Appendix I. Subjects received an explanation and demonstration of each item prior to performing the test. Mistrials were repeated at the end of each group. Times are recorded to the nearest one-tenth of a second. Subjects were grouped in pairs for the 50 yard dash and the 300 yard run. Verbal encouragement was expressed to all participants throughout the testing.

The presentation of the CAHPER Fitness - Performance test items did proceed in a particular order. They were organized so as to accommodate all twenty-five subjects in an orderly and efficient manner. The subjects were randomly assigned to either of six groups and instructed to remain with that group throughout the duration of the tests. The spacial outlay of the gymnasium afforded the opportunity to establish stations at various intervals throughout the gym. An instructor was located at each station to explain, demonstrate and record the results. Subjects rotated from station to station at the completion of each test. The rotation system was organized so that the proceeding station did not stress the same muscle group as the previous station. Thus, the stations were arranged in the following order: (1) 50 yard dash, (2) flexed arm hang, (3) shuttle run, (4) speed sit-ups, (5) standing broad jump, (6) 300 yard run.

Physical Work Capacity Test

The PWC 170 test was conducted according to the procedure of Howell and Macnab (25). Each subject was instructed to rest prior to the test. The saddle height was also for each subject. A three lead electrode system (Einthoven Triangle) was used to record heart rate on a Sanborn 500 Viso-Cardiette electrocardiogram. A pre-exercise heart rate was recorded. A modified stationary bicycle ergometer (Monarch) as described by Howell and Macnab (25) was employed to complete the PWC 170 tests. The bicycle was calibrated prior to testing according to the procedure of Howell and Macnab (25). The calibrations are recorded in Appendix A.

Each subject pedalled the ergometer continuously for a maximum of twelve minutes in three consecutive intervals of four minutes each. The cadence, 60 revolutions per minute was maintained with the aid of an electric metronome. Pedal revolutions were counted using a pedal revolution counter which was attached to the bicycle. The revolutions were recorded at each of the four minute intervals.

Statistical Procedure

Means and standard deviations were calculated for each parameter. All computations were made with an IBM 360 computer at the University of Alberta. The difference between post season group scores and the difference of means between testing sessions were employed to measure and evaluate the performance of each group.

RESULTS AND DISCUSSION

Anthropometric Measures

The names and dates of each subject of both groups are presented in Appendix B. Also, included in Appendix C, are the raw physical characteristic scores for each subject. Members of both groups are nine years of age as of December 31, 1974.

Post season means and standard deviations for both groups are listed in Table II. The post season means are 116.0 months for the control group and 118.1 months for the hockey group. This discrepancy is attributed to the fact that four members of the hockey group and only one member from the control group were ten years of age at the time of post season testing.

Mean height and weight measures are greater for the hockey group at post season. On the average the hockey group is 0.9 inches taller and 1.5 pounds heavier than the control group. As expected, from post season 1974 to post season 1975, the respective group means (Table III) improved considerably. The mean height value of the control group improved from 51.5 to 53.5 inches, an average of 2.0 inches. The hockey group averaged an increase of 1.7 inches. The hockey group gained an average of 5.7 pounds compared to an average increase of 6.3 pounds for the control group. There was a substantial improvement in mean scores over the period of one year, however, the mean height and weight scores between the groups at post season are minimal. This may in part be attributed to the difference in sample sizes.

At post season 1975 (Table II) the hockey group means for bi-iliac and bi-acromial width are slightly greater than the mean values for the

TABLE II

PHYSICAL CHARACTERISTICS SUBJECTS

(POST SEASON 1975)

MEANS AND STANDARD DEVIATIONS

GROUP	AGE (MONS)	HEIGHT (INS.)	WEIGHT (LBS.)	BI-ILIAC (CM)	BI-ACROMIAL (CM)
CONTROL	116.0	53.5	66.2	20.6	28.1
	2.6	2.87	9.15	1.3	3.0
HOCKEY	118.1	54.4	67.7	21.3	29.6
	3.13	1.83	9.05	1.10	1.06

TABLE III

PHYSICAL CHARACTERISTICS OF SUBJECTS

A COMPARISON OF POST SEASON MEANS

(1974 vs. 1975)

GROUP	AGE (MONS)	HEIGHT (INS.)	WEIGHT (LBS.)	BI-ILIAC (CM)	BI-ACROMIAL (CM)
CONTROL					
* 1974	103.7	51.5	59.9	20.1	27.9
	2.74	2.74	8.09	1.45	0.93
1975	116.0	53.5	66.2	20.6	28.1
	2.61	2.87	9.15	1.32	3.01
HOCKEY					
1974	105.6	52.7	62.0	20.4	28.5
	2.78	1.79	7.28	0.8	0.8
1975	118.1	54.4	67.7	21.3	29.6
	3.13	1.83	9.05	1.10	1.06

* Means and Standard Deviations are adjusted for eleven subjects.

control group. Both group means improved over the one year period (Table III). The hockey group appeared to improve slightly more than the control group. The difference in post season means for bi-iliac width are 0.9 cm for the hockey group and 0.5 cm for the control group. For bi-acromial width, the difference in post season means are 1.1 cm for the hockey group and 0.2 cm for the control group. These differences would appear to suggest that the hockey group is improving at a faster rate than the control group, particularly with regards to bi-acromial development.

Thus, over the period of one year the difference between means of these parameters seem to suggest that the hockey group improved at a greater rate, with the exception of bi-iliac width.

Grip Strength

The post season 1975 raw grip strength scores for both groups are listed in Appendix D. The post season 1975 means and standard deviations for the hockey and control groups are recorded in Table IV. Figure I shows the changes in the control and hockey group mean scores over the duration of a year and three months. The national mean scores for boys of the same age are also listed.

At post season 1975 (Table IV), the hockey group mean left and right grip strength values are greater than the control group means. The mean values for the former group are 44.2 lbs. for the left and 46.5 lbs. for the right. The control group means are 41.9 and 45.4 respectively. The differences between post season means are 2.3 lbs. and 1.1 lbs. for the left and right grips respectively.

Over the period of one year, April 1974 to 1975, the difference in post season means (Table V) for both right and left grip seems to

TABLE IV

POST SEASON 1975 MEAN GRIP STRENGTH VALUES

GROUP	LEFT GRIP (LBS.)	RIGHT GRIP (LBS.)
CONTROL	41.9	45.4
	9.9	8.8
HOCKEY	44.2	46.5
	8.8	9.3

suggest that the control group improved at a greater rate. This is also apparent by an inspection of Figure I. The control means for left and right grip strength improved by 4.1 lbs. for the former and 6.1 lbs. for the latter. The hockey groups mean left grip score improved 0.9 lbs. and the right grip mean improved by 3.6 lbs. This may be partly attributed to a combination of two factors. The difference in sample sizes, especially for the control group may account for less variation in range. Secondly, it would appear from the difference in post 1974 mean grip strength values, since the hockey group recorded considerably higher mean score than the control group, the latter's rate of improvement would be less dramatic than the control groups.

For the most part, studies related to the measurement of grip strength have been designed to establish standards and/or sex and age differences. A survey of mean grip strength values for nine year old males is presented in Table VI. By inspection, it is apparent that the mean left and right grip strength mean values of the grips in the present study are comparable and in most cases greater than other reported values. In comparison to the means values reported by Howell <u>et al</u>. (26), on the Edmonton school population, the means reported in the present study are much greater for the same age group. Both the control and hockey group means in the present study are greater than the mean grip strength values of the ten year olds in the Howell report (26). The variability in means values may in part be attributed to the samples and their respective sizes. The values reported by Howell <u>et al</u>. (26) may be more representative of nine and ten year olds.

TABLE V

COMPARED POST SEASON GRIP STRENGTH

GROUP	LEFT GRIP (LBS.)	RIGHT GRIP (LBS.)
CONTROL 1974	37.8	39.3
	6.98	7.28
1975	41.9	45.4
	9.87	8.83
HOCKEY 1974	43.3	42.9
	7.4	6.5
1975	44.2	46.5
	8.8	9.3

TABLE VI

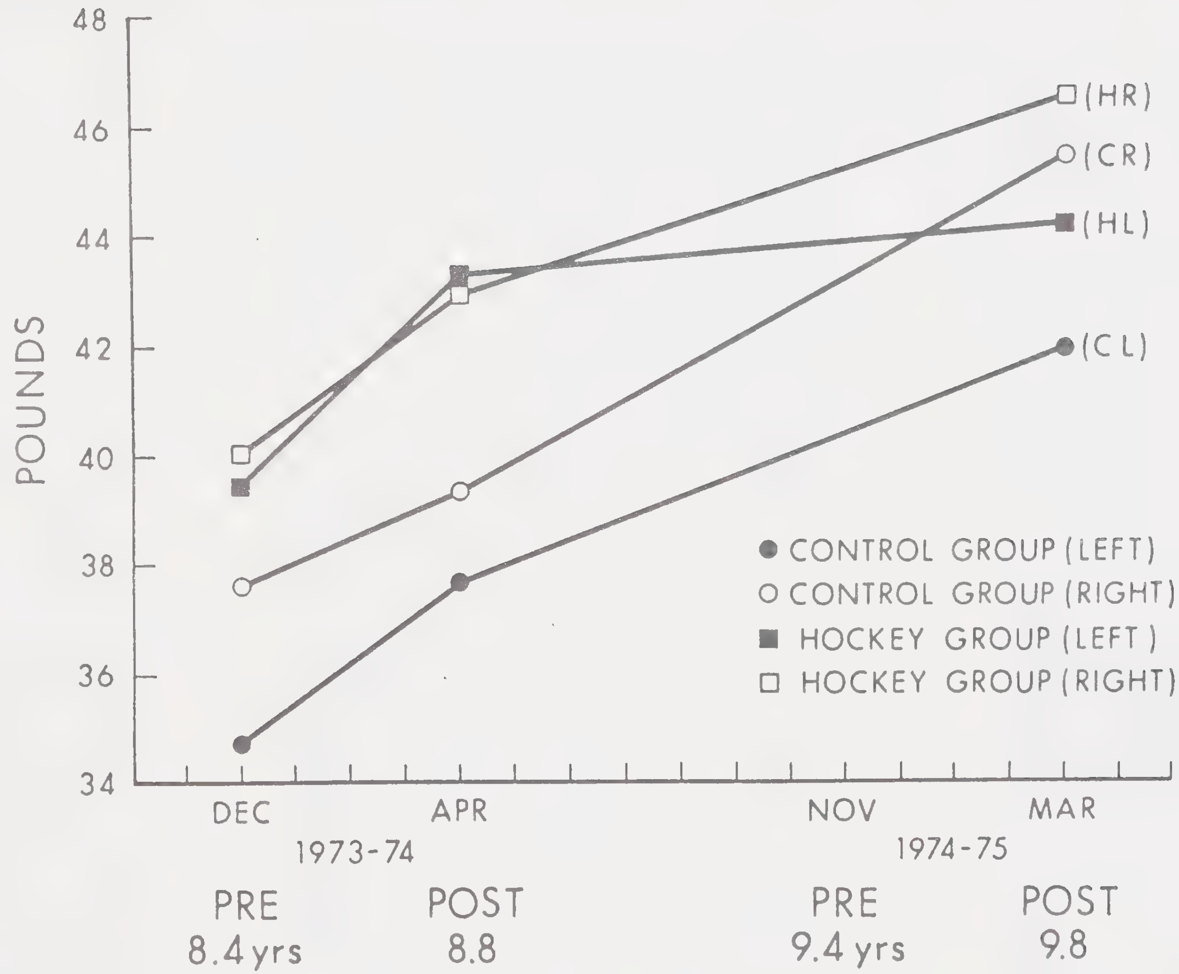
COMPARED GRIP STRENGTH MEASUREMENTS

AUTHOR(S)	PLACE	AGE (YRS.)	N.	LEFT GRIP (LBS.)	RIGHT GRIP (LBS.)
GILL (C)	EDMONTON	9.6	11	41.9	45.4
(H)		9.8	14	44.2	46.5
THIBAULT (C)	EDMONTON	8.6	14	37.8	39.3
(H)	EDMONTON	8.8	14	43.3	42.9
COOK AND FRAZEK (C)	EDMONTON	9.3	14	49.1	54.1
(H)		9.8	14	53.2	58.3
(G)		9.3	9	47.5	51.0
HOWELL	EDMONTON	9.0	36	36.2	37.7
		10.0	36	40.6	42.7
BOOKWALTER	MICHIGAN	9.0	-	42	43.0

(C) - Control Group, (H) - Hockey Group, (G) - Gymnastic Group

FIGURE 1

GRIP STRENGTH CHANGES IN MEAN VALUES



CAHPER Fitness - Performance Items

The individual scores and group means for the various subtest items of both the control and hockey groups are listed in Appendix E. Figures 2 through 7 inclusively, monitor the changes in the control and hockey group mean values over the duration of a year and three months. Also included in these figures are national means for boys of the same age.

50 Yard Dash

The hockey group mean post season 1975 score was 8.3 secs. compared to a mean of 8.6 secs. for the control group; a mean difference of 0.3 seconds between groups. Over the period of twelve months, both groups improved their respective scores. The control group mean improved 0.4 secs., from 9.0 to 8.6 secs., and the hockey group improved from 8.9 to 8.3 secs., a difference of 0.6 seconds. The difference between post season means appears to suggest that the hockey group improved at a faster rate. This observation is exemplified in Figure 2. The slope of the hockey group line appears to change more dramatically than the others.

300 Yard Run

The hockey group mean was 2.4 secs. faster than the control group mean at post season 1975. Both groups improved their respective mean scores over the duration of twelve months. The difference between post season means for the control group was 4.6 secs. compared to 3.4 secs. for the hockey group. This would seem to suggest that the control group improved at a faster rate over the period of one year. The difference between the slopes of the lines between the two groups in Figure 3 appears to verify this observation. This may be confounded by a com-

TABLE VII

POST SEASON 1975 C.A.H.P.E.R. PERFORMANCE VALUES

MEANS AND STANDARD DEVIATIONS

	N	50 YD. (SECS.)	300 YD. (SECS.)	SHUTTLE RUN (SECS.)	FLEX. ARM HANG (SECS.)	STND. BRD. JUMP (INS.)	1 MIN. SPEED SIT-UPS (NO.)
CONTROL	11	8.6	67.5	12.7	53.5	58.2	30.9
		0.3	2.9	0.9	22.7	5.8	5.5
HOCKEY	14	8.3	65.1	11.8	80.3	60.8	39.9
		0.4	1.8	0.5	33.0	5.2	6.3

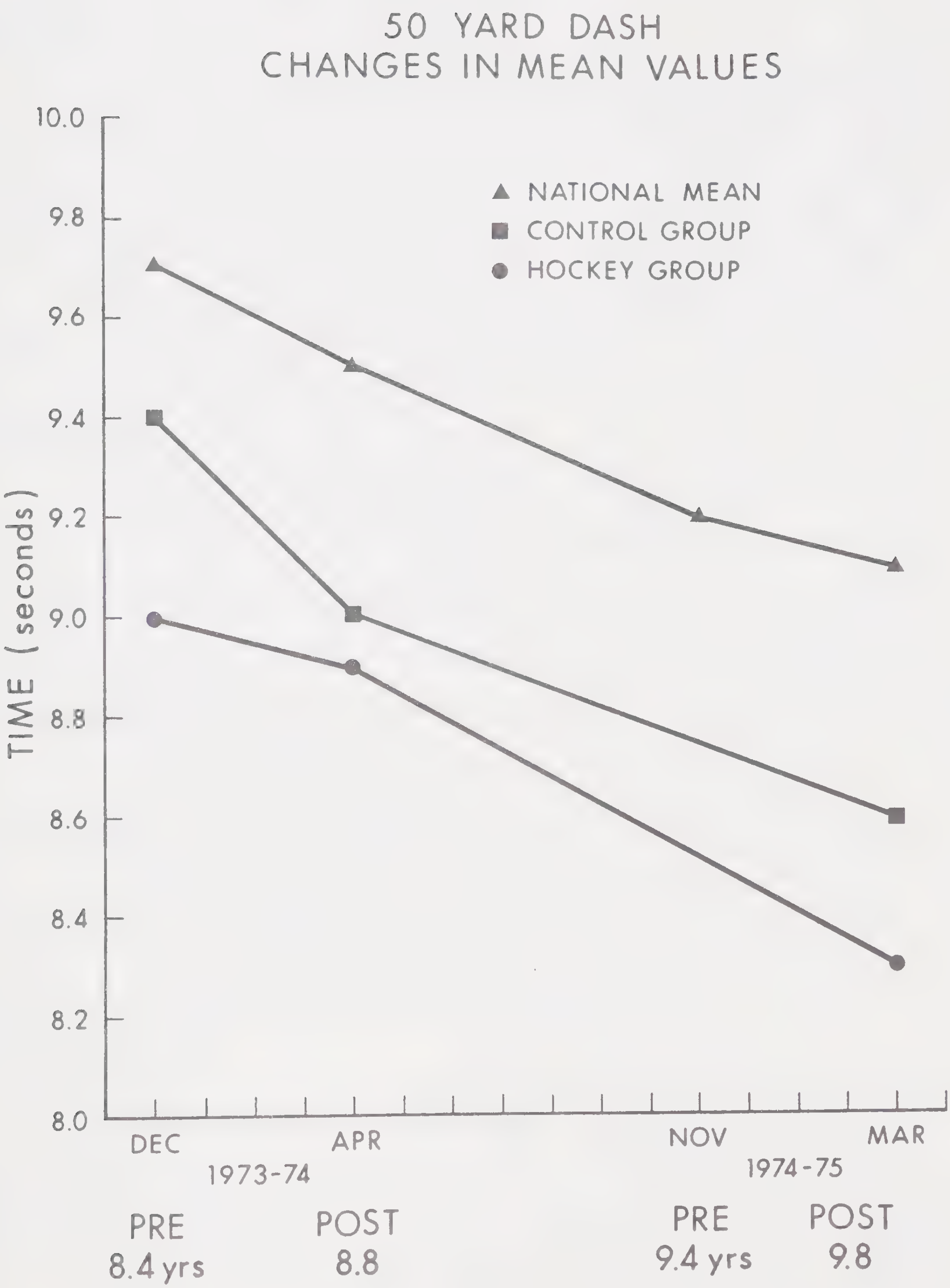
TABLE VIII

COMPARED POST SEASON C.A.H.P.E.R. PERFORMANCE MEAN

GROUP	N	50 YD. (SECS.)	300 YD. (SECS.)	SHUTTLE RUN (SECS.)	FLEX. ARM HANG (SECS.)	STND. BRD. JUMP (INS.)	1 MIN. SPEED SIT-UPS (NO.)
CONTROL							
* POST - 74	11	9.0	72.1	12.8	17.0	50.5	23.9
POST - 75	11	8.6	67.5	12.7	53.5	58.2	30.9
HOCKEY							
POST - 74	14	8.9	68.5	11.8	57.7	55.7	30.1
POST - 75	14	8.3	65.1	11.8	80.3	60.8	39.9

* Corrected means for 11 subjects.

FIGURE 2


50 YARD DASH
CHANGES IN MEAN VALUES
NATIONAL MEAN
CONTROL GROUP
HOCKEY GROUP
TIME (seconds)
10.0
9.8
9.6
9.4
9.2
9.0
8.8
8.6
8.4
8.2
8.0
DEC
APR
NOV
MAR
1973-74
1974-75
PRE
8.4 yrs
POST
8.8
PRE
9.4 yrs
POST
9.8

parison of respective sample sizes.

Shuttle Run

The post season (1975) means revealed that the hockey group was 0.9 secs. faster than the control group mean. Neither group appeared to improve over the duration of one year as the respective mean scores did not change. An inspection of Figure 4 indicates that the slopes of the lines are relatively linear, suggesting little or no change in group mean scores over the duration of a year and three months.

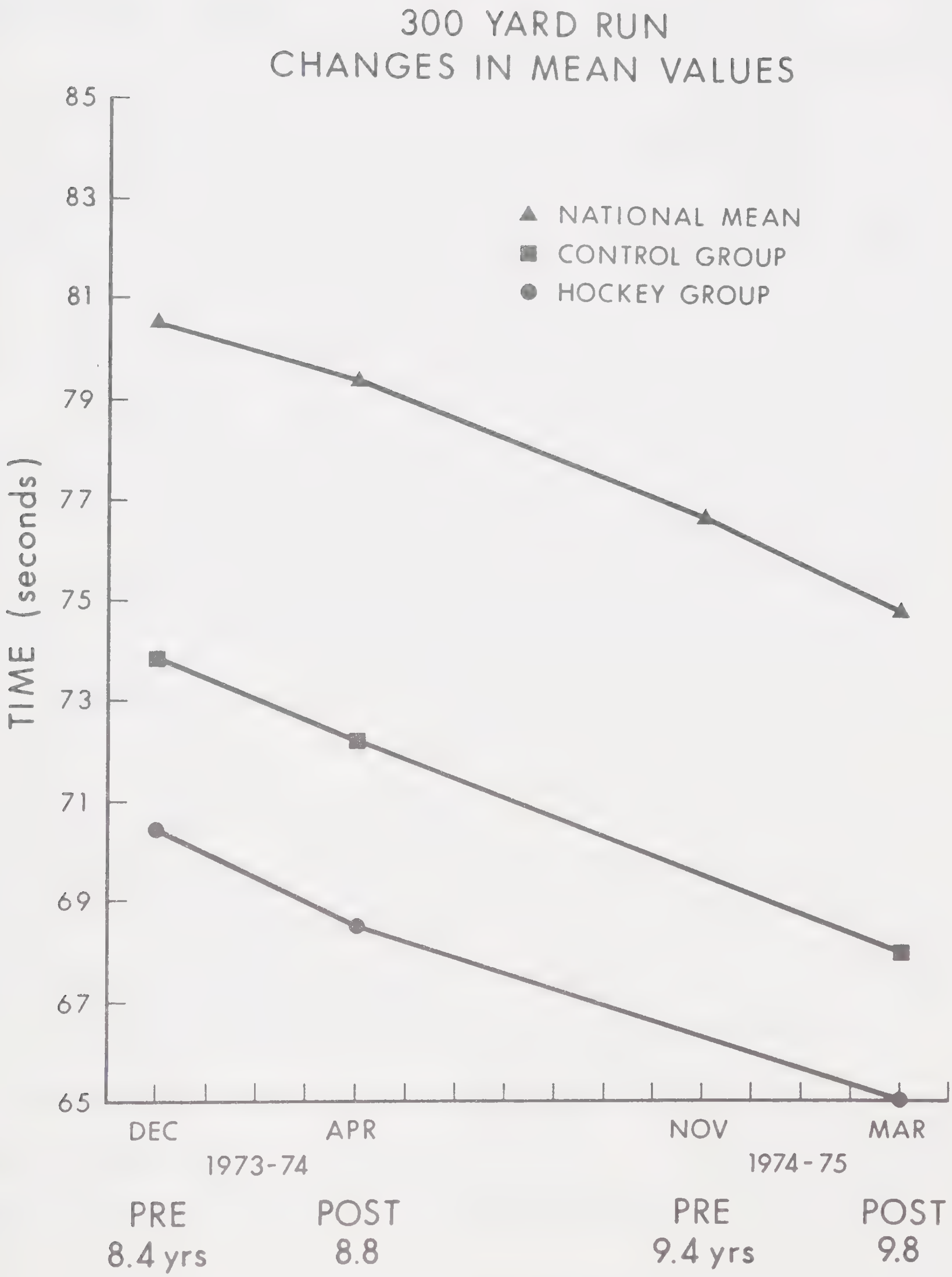
Flexed Arm Hang

The mean hockey group score was 80.3 secs. compared to 53.3 secs. for the control group. The mean difference between groups was 26.8 secs., substantial enough to suggest significance. The hockey group improved 22.6 secs. over the duration of one year compared to an improvement of 36.5 secs. over the same time period. The difference in means between testing periods seems to suggest that the control group improved at a faster rate. This would be expected as their post season (1974) mean was 17.0 seconds. This observation is exemplified in Figure 5, as the slope of the control group line appears to be greater than that of the hockey group.

Standing Long Jump

The post season mean for the hockey group was 60.8 inches compared to 58.2 inches for the control group. The difference between means was 2.6 inches. The difference in means between testing periods seems to suggest a greater improvement for the control group. Over the period of one year the control group improved 7.7 inches compared to an improvement of 5.1 inches for the hockey group. The difference in the slopes of the lines between the two groups in Figure 6 appears

FIGURE 3


300 YARD RUN
CHANGES IN MEAN VALUES
85
83
81
79
77
75
73
71
69
67
65
TIME (seconds)
NATIONAL MEAN
CONTROL GROUP
HOCKEY GROUP
DEC
APR
NOV
MAR
1973-74
1974-75
PRE
8.4 yrs
POST
8.8
PRE
9.4 yrs
POST
9.8

to verify this observation.

1 Minute Speed Sit-Ups

The hockey group post season mean was 9.0 greater than the control group. The difference in means between testing sessions was 9.8 compared to 7.0 for the control group. This difference seems to suggest that the hockey group improved at a faster rate. The differences in the slopes of the lines of the two groups in Figure 7 appears to compliment this observation.

In retrospect, the control group appeared to be inferior to the hockey group in all post season 1975 mean scores (Table VII). However, it is apparent by an inspection of the difference in means between testing periods (Table VIII) that the control group appeared to show a greater amount or rate of improvement over the duration of one year, with two exceptions being the 50 yard dash and the speed sit-ups. Crawford (13) indicated that the performance tests are dependent on body size of the subjects. Since both the control and hockey groups in the present study increased their respective body weights by virtually the same amount over one year (Table II), it would seem legitimate to suggest that the control groups' performance was truly an improvement. Montoye, et al. (35) indicated that it was not necessary to be concerned about differences in height and weight of male boys in the same age category. This explanation also lends credence and supports the absolute improvement of the control group.

By inspection of Table IX, it is readily apparent that the mean scores of both the present control and hockey groups are better than the other scores reported. In comparison to the national norms

FIGURE 4

SHUTTLE RUN CHANGES IN MEAN VALUES

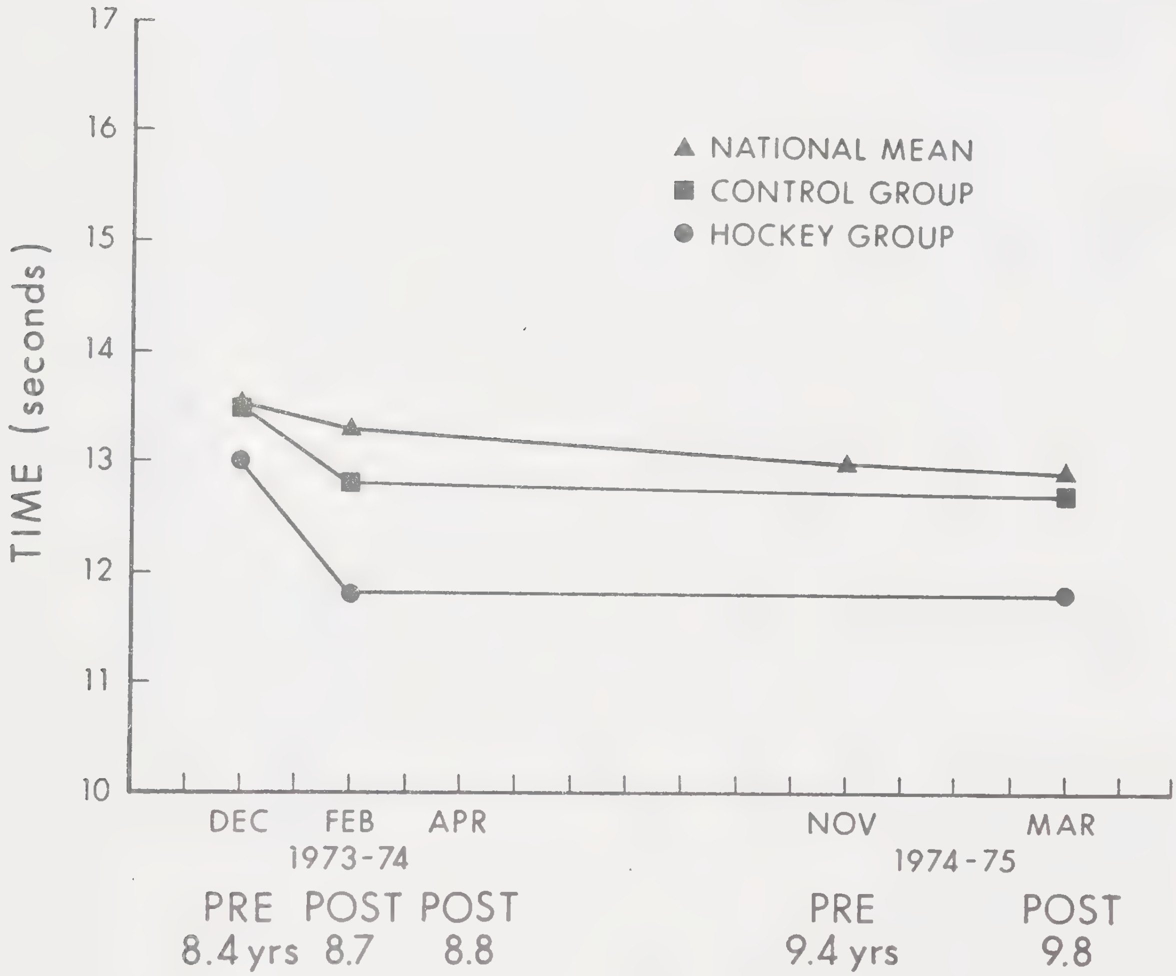


FIGURE 5

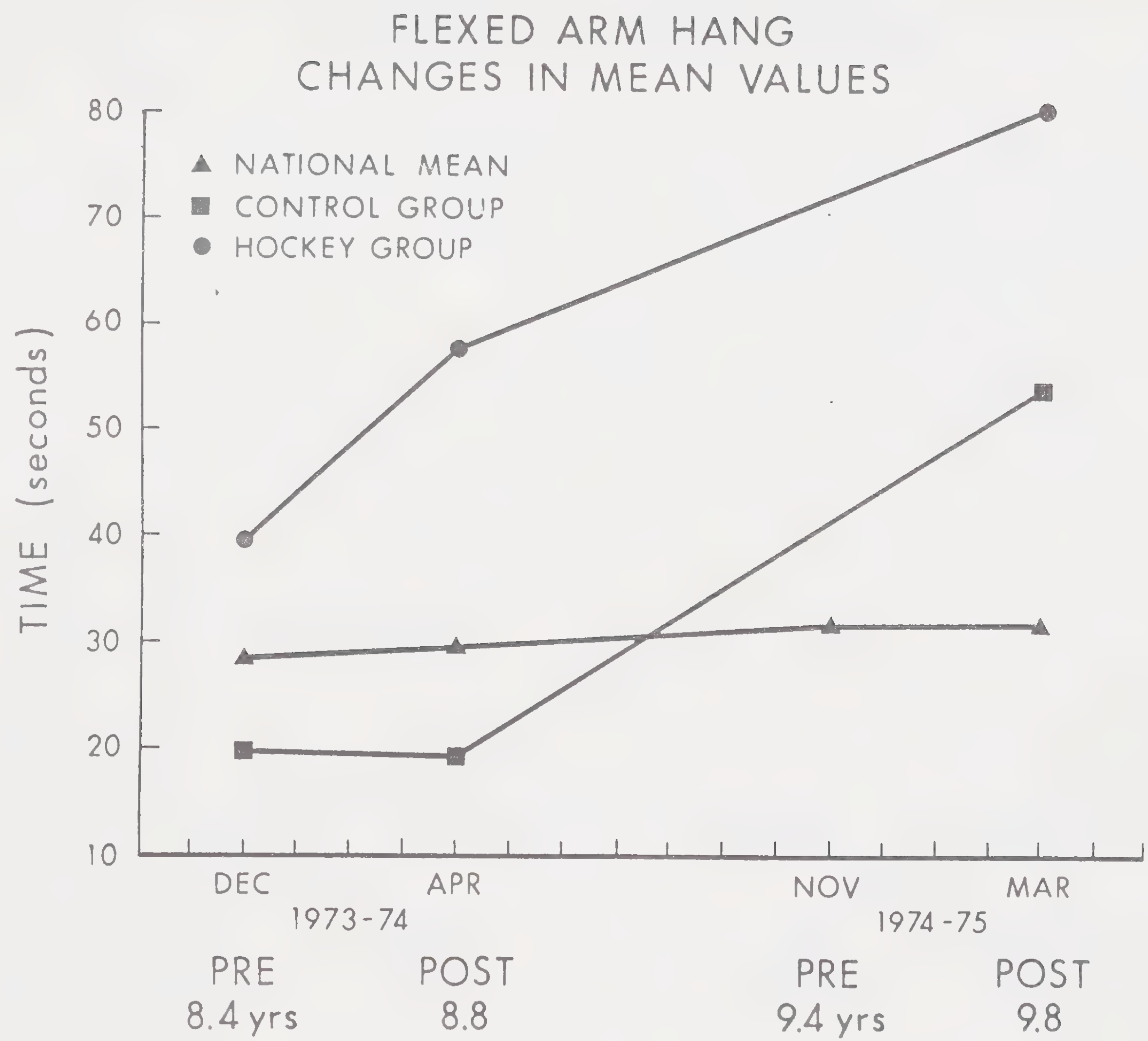

FLEXED ARM HANG
CHANGES IN MEAN VALUES
NATIONAL MEAN
CONTROL GROUP
HOCKEY GROUP
TIME (seconds)
80
70
60
50
40
30
20
10
DEC
APR
NOV
MAR
1973-74
1974-75
PRE
8.4 yrs
POST
8.8
PRE
9.4 yrs
POST
9.8

FIGURE 6

STANDING LONG JUMP
CHANGES IN MEAN VALUES

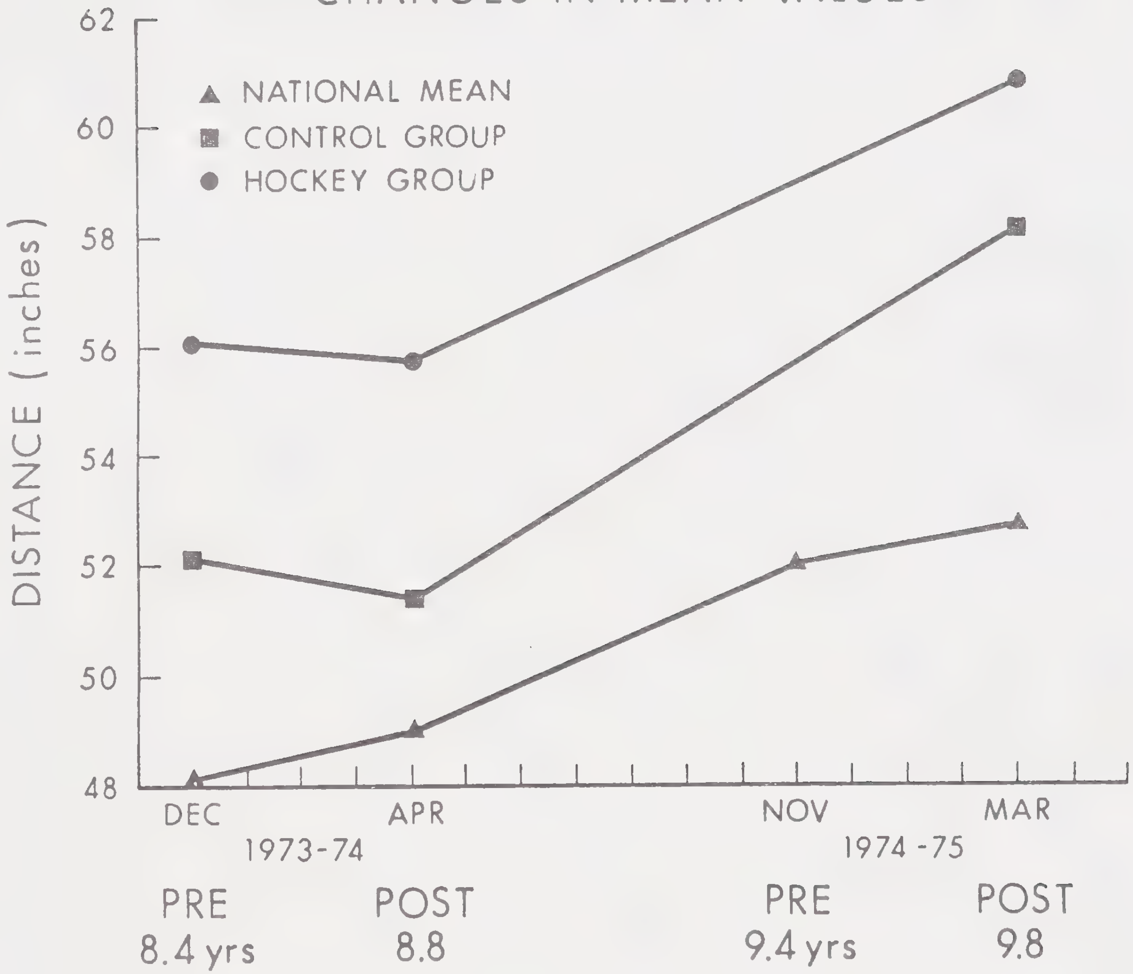


FIGURE 7

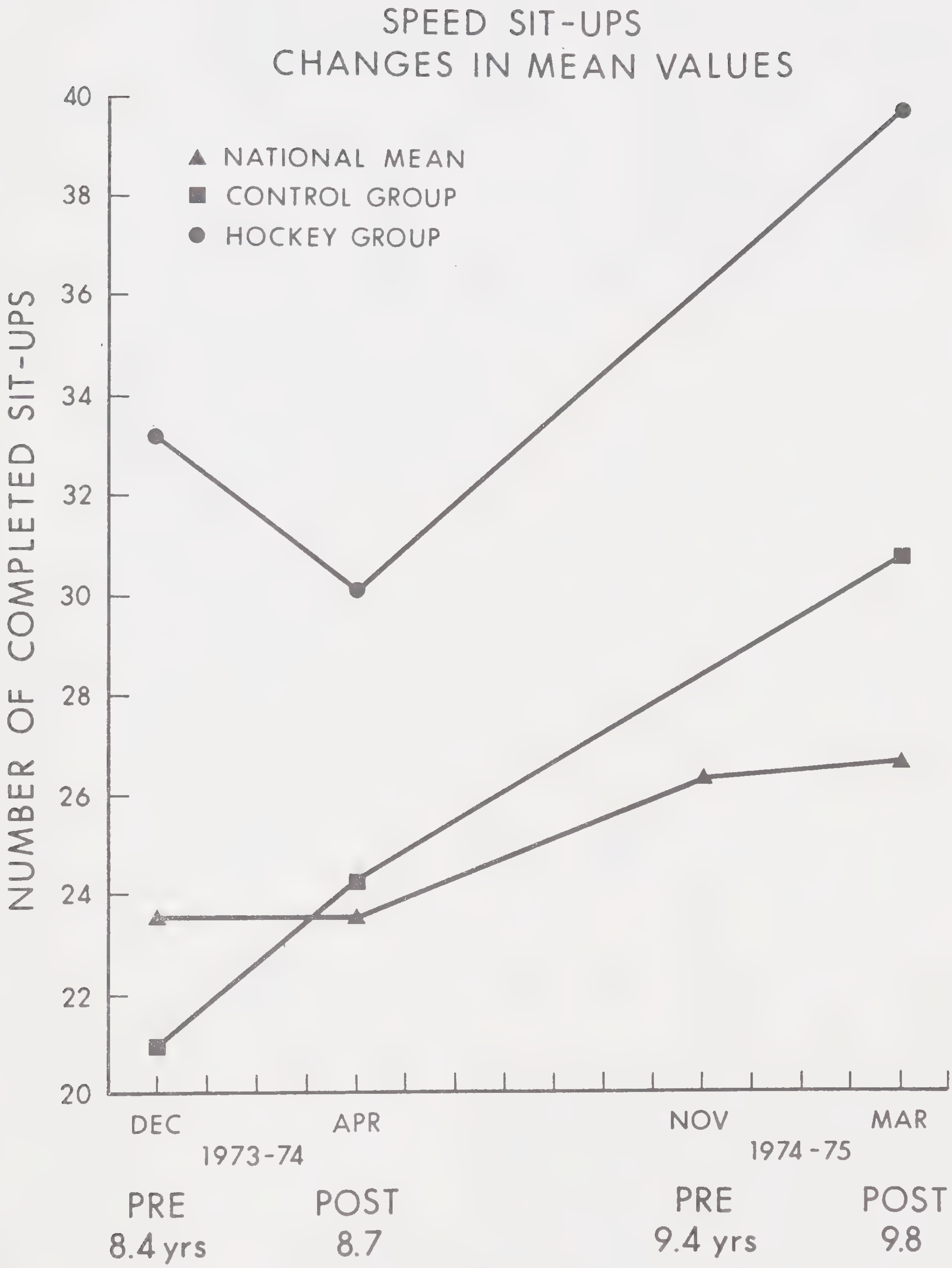

SPEED SIT-UPS
CHANGES IN MEAN VALUES
NATIONAL MEAN
CONTROL GROUP
HOCKEY GROUP
NUMBER OF COMPLETED SIT-UPS
40
38
36
34
32
30
28
26
24
22
20
DEC
APR
NOV
MAR
1973-74
1974-75
PRE
8.4 yrs
POST
8.7
PRE
9.4 yrs
POST
9.8

TABLE IX

COMPARED C.A.H.P.E.R. PERFORMANCE MEASUREMENTS

AUTHOR(S)	N	50 YD. (SECS.)	300 YD. (SECS.)	SHUTTLE RUN (SECS.)	FLEX. ARM HANG (SECS.)	STND. BRD. JUMP (INS.)	1 MIN. SPEED SIT-UPS (NO.)
* GILL (C)	11	8.6	67.5	12.7	53.5	58.2	30.9
(H)	14	8.3	65.1	11.8	80.3	60.8	39.9
C.A.H.P.E.R.							
9 year olds	584	9.2	76.7	12.9	31.4	52	26.4
10 year olds	499	8.8	73.8	12.8	32.8	54	27.3
CUMMING							
9 year olds	41	8.9	76	12	27	52	29
10 year olds	10	9.1	80	13	19	58	28

* Control subjects' mean age is 9.6

Hockey subjects' mean age is 9.8

established and published by CAHPER (12), the control and hockey mean scores are considerably better. Even compared to the mean scores for the next age bracket (10 year olds), the group's mean score from the present study are substantially better. The same trend occurs with regards to the values reported by Cumming and Keynes (18), in comparison to both age categories, the mean scores of the present investigation are superior. These discrepancies may in part be attributed to the conspicuous sample size differences, especially in the case of the national sample. The present sample may not be totally representative of their sex and age group.

Hockey Skill Tests

The pre and post season hockey skill test results are presented in Appendix F. Individual, as well as pre and post season means, are listed for each test item. A description and diagramatic representation of each test is presented in Appendix J. Pre and post season means and standard deviations are listed in Table IX. Figures 8 through 11 inclusively show the changes in mean values over the period of fourteen months. The results are described for each individual test item.

Forward Linear Skate

The pre and post season means are listed in Table X. There appeared to be a fairly substantial improvement in the linear skate. With regards to the "acceleration phase" (Hansen, 24) or the first 90 feet, the mean improved from 4.9 to 4.5 seconds or 0.4 seconds. Proportionately, the greatest amount of improvement occurred between the distances of 60 and 90 feet where the mean score improved by 0.3 seconds compared to 0.1 over the first 60 feet. Between 90 and 120

TABLE X

HOCKEY SKILL TESTS

PRE AND POST SEASON MEANS AND STANDARD DEVIATIONS

		FRONT SKATING			BACKWARD SKATING				PUCK CONTROL		MACNAB
		60'	90'	120'	60'	90'	120'	AGILITY	MOD. MARCOTTE	HANSEN	GILL
PRE	M	3.3	4.9	6.4	4.8	7.0	9.2	12.2	17.4	24.6	
	S.D.	0.2	0.3	0.3	0.4	0.6	0.8	0.8	1.2	1.8	
POST	M	3.2	4.5	5.8	4.5	6.2	8.1	11.3	16.3	21.6	12.5
	S.D.	0.3	0.2	0.2	0.4	0.5	0.6	0.6	0.9	1.6	

All scores are recorded to nearest one-tenth of a second.

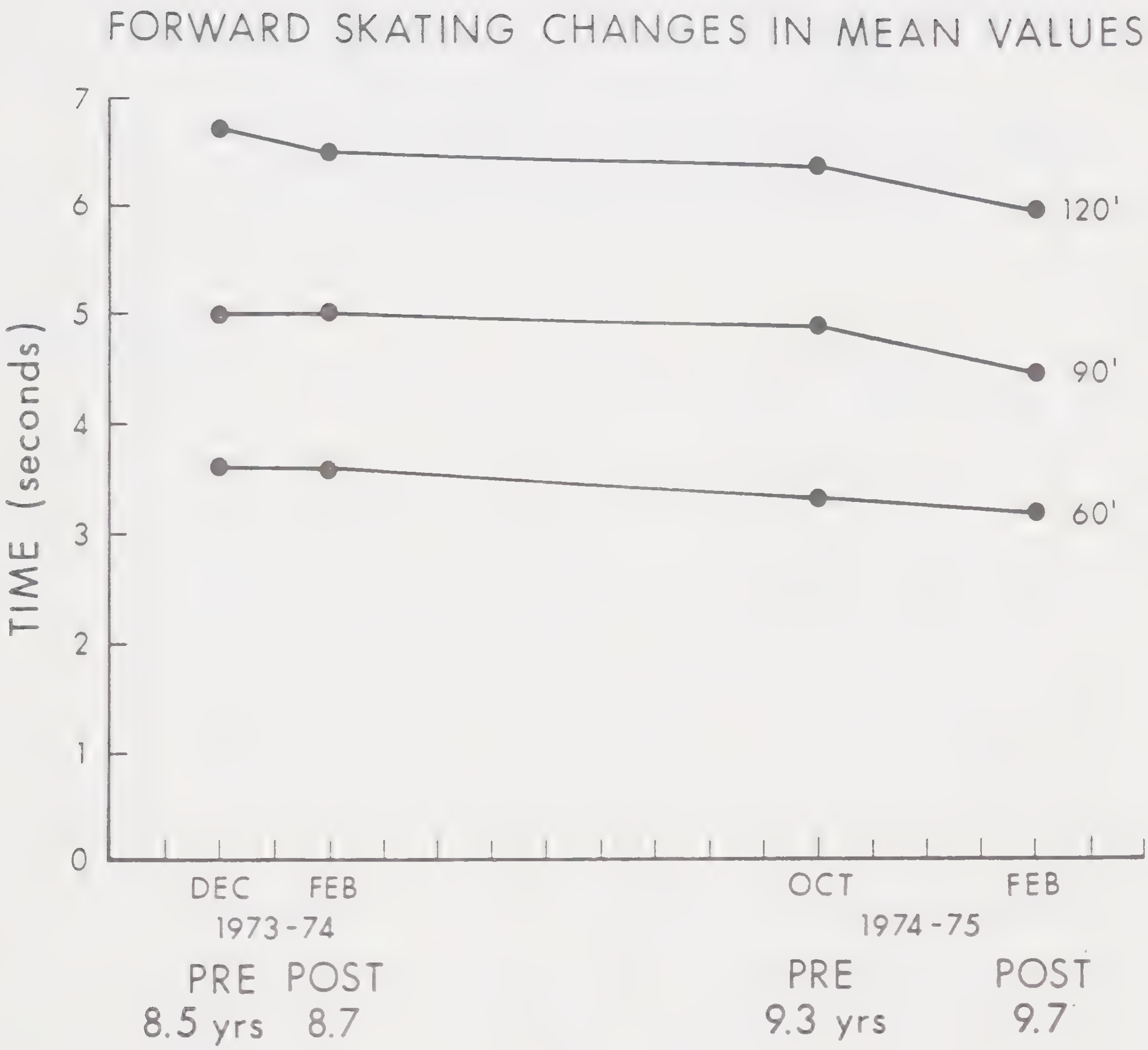
TABLE XI

COMPARED POST SEASON HOCKEY SKILL

MEANS AND STANDARD DEVIATIONS

			FRONT SKATING			BACKWARD SKATING				
			60'	90'	120'	60'	90'	120'	AGILITY	MOD. MARCOTTE (PUCK CONTROL)
POST	1974	M.	3.6	5.0	6.5	5.4	7.7	10.2	12.7	18.5
		S.D.	0.2	0.2	0.3	0.3	0.6	0.6	0.6	1.1
POST	1975	M.	3.2	4.5	5.8	4.5	6.2	8.1	11.3	16.3
		S.D.	0.3	0.2	0.2	0.4	0.5	0.6	0.6	0.9

FIGURE 8


FORWARD SKATING CHANGES IN MEAN VALUES
TIME (seconds)
0
1
2
3
4
5
6
7
120'
90'
60'
DEC
FEB
1973-74
OCT
FEB
1974-75
PRE
POST
8.5 yrs
8.7
PRE
POST
9.3 yrs
9.7

feet or "speed phase" as referred to by Hansen (24), the difference between pre and post season means indicated an improvement of 0.2 seconds. Thus, over the entire distance of 120 feet, the post season mean improved by 0.6 seconds. Over the duration of one year (Table XI) the mean difference between testing periods was 0.7 seconds.

These changes in mean values are diagramatically represented in Figure 8. The change in the slope of the lines between October 1974 and February 1975 appear to be most dramatic.

Backward Skating

By inspection of the mean scores for backward skating (Table X), the differences between pre and post season means indicates an overall improvement of 1.1 seconds. During the first two-thirds of the "acceleration phase" the difference between pre and post season means was 0.3 seconds and during the latter one-third the difference was 0.5 seconds, a total improvement of 0.8 seconds during the "acceleration phase". The difference between means over the "speed phase" was 0.3 seconds.

Over the duration of one year, the present group improved their backward skating performance substantially. The mean difference between post season testing periods was 2.1 seconds. This observation is exemplified by the change in the slopes of the lines between October 1974 and February 1975 in Figure 9. The differences in slopes appears to be most dramatic at 90 and 120 feet.

Hansen's Agility Skate

The pre season mean score for the hockey group to complete the agility skate was 12.2 seconds compared to 11.3 seconds at post season. The difference between means suggests an improvement of 0.9 seconds.

FIGURE 9

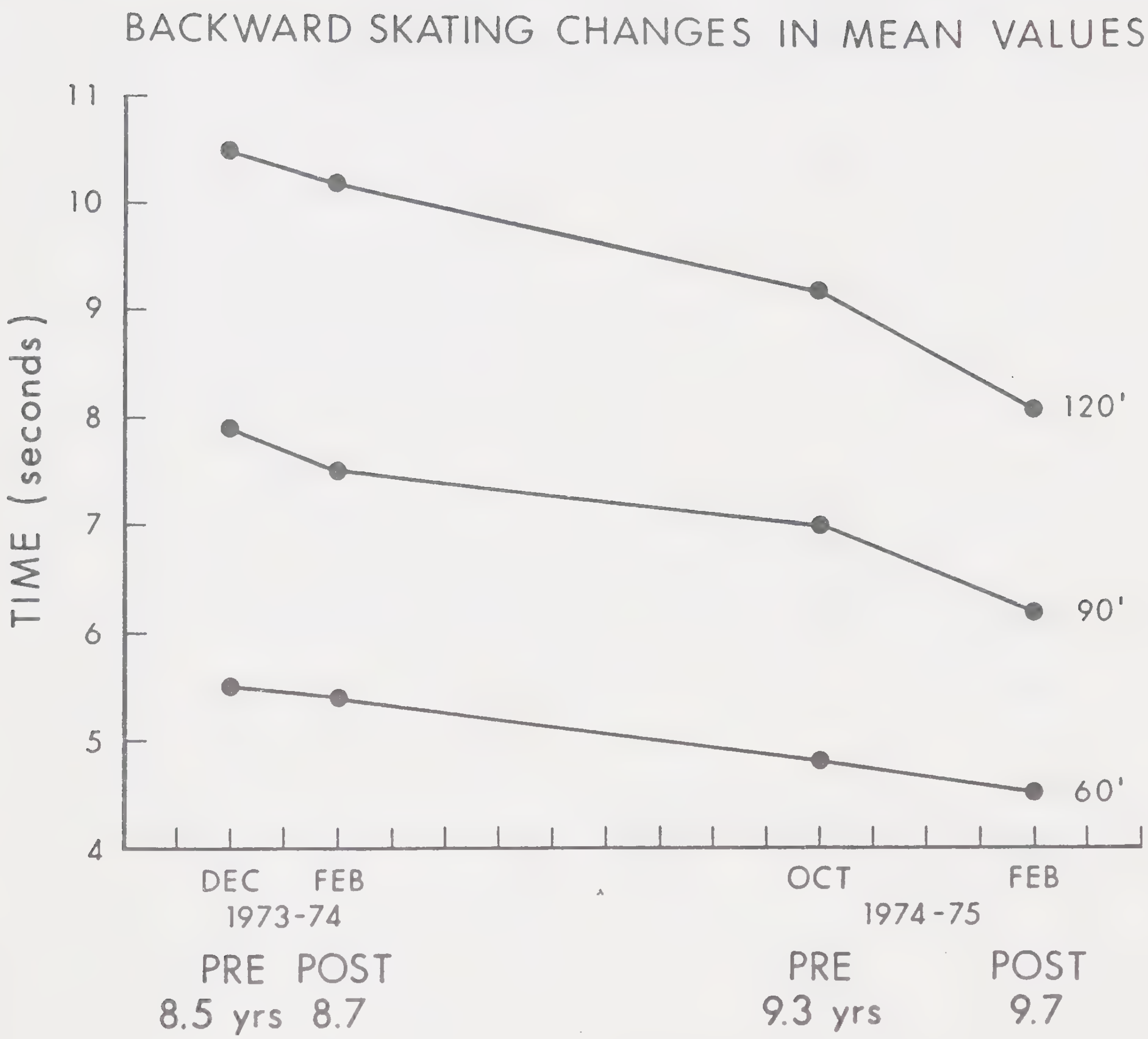
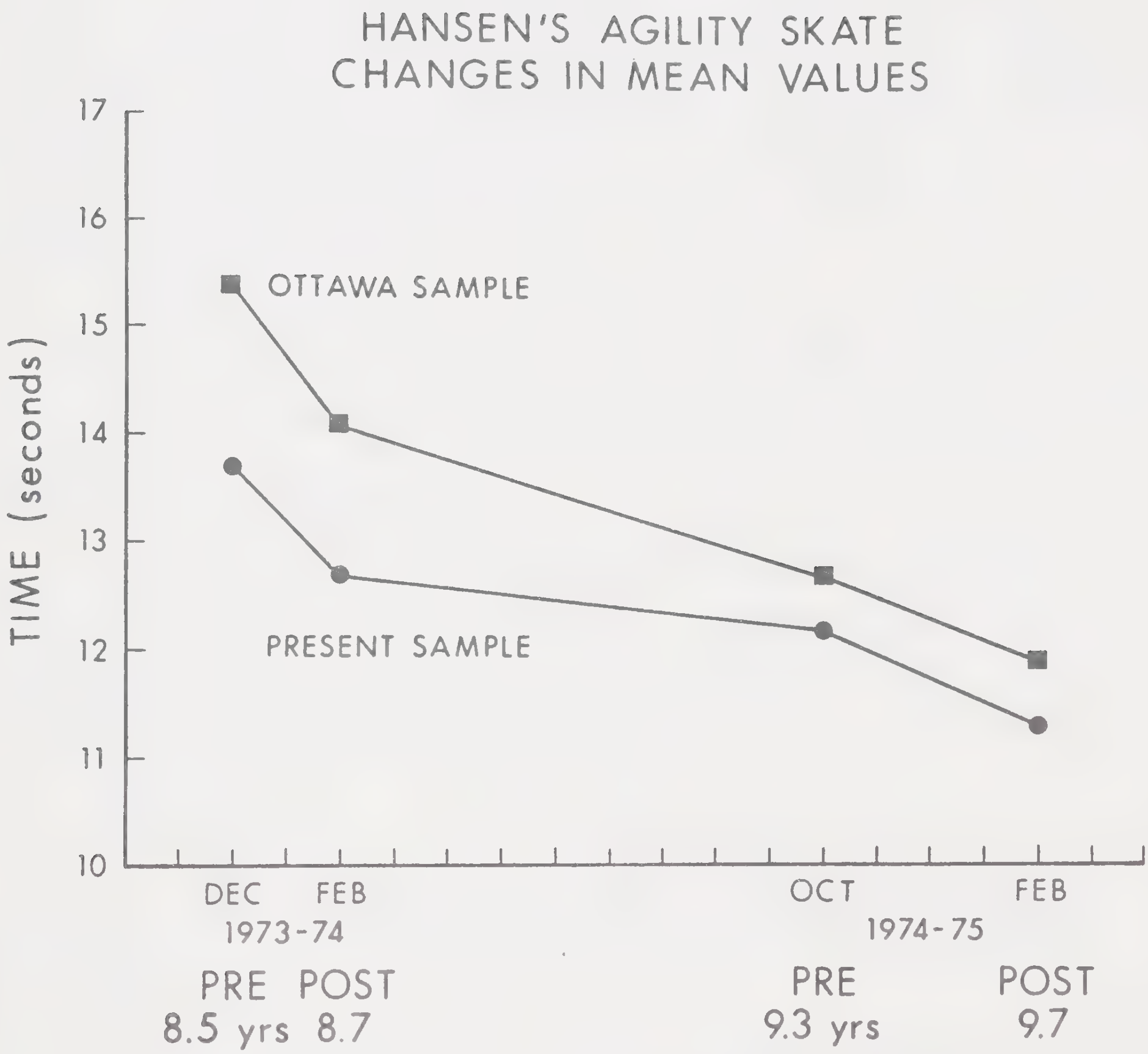

BACKWARD SKATING CHANGES IN MEAN VALUES
TIME (seconds)
11
10
9
8
7
6
5
4
120'
90'
60'
DEC
FEB
1973-74
OCT
FEB
1974-75
PRE
POST
8.5 yrs
8.7
PRE
POST
9.3 yrs
9.7

FIGURE 10


HANSEN'S AGILITY SKATE
CHANGES IN MEAN VALUES
TIME (seconds)
17
16
15
14
13
12
11
10
OTTAWA SAMPLE
PRESENT SAMPLE
DEC
FEB
1973-74
OCT
FEB
1974-75
PRE
POST
8.5 yrs
8.7
PRE
POST
9.3 yrs
9.7

The mean difference between testing periods, over the period of one year, was 1.4 seconds. The slope of the line between pre and post season test sessions in the present study in Figure 10 exemplifies this improvement. Also, the difference in slopes between the Ottawa and present sample over the same period appears to indicate a slightly greater amount of improvement in favour of the present sample.

Puck Control Tests

(a) Modified Marcotte

The pre season mean was 17.4 seconds compared to 16.3 seconds at post season. The difference between means suggests an improvement of 1.1 seconds.

The post season 1974 mean was 18.5 seconds. The mean difference between testing periods was 2.2 seconds over the duration of one year. This improvement is apparent in Figure 11. The slope of the line suggests a marked difference.

(b) Hansen

The pre season mean score was 24.6 seconds compared to a post season mean score of 21.6 seconds, a mean difference or improvement of 3.0 seconds.

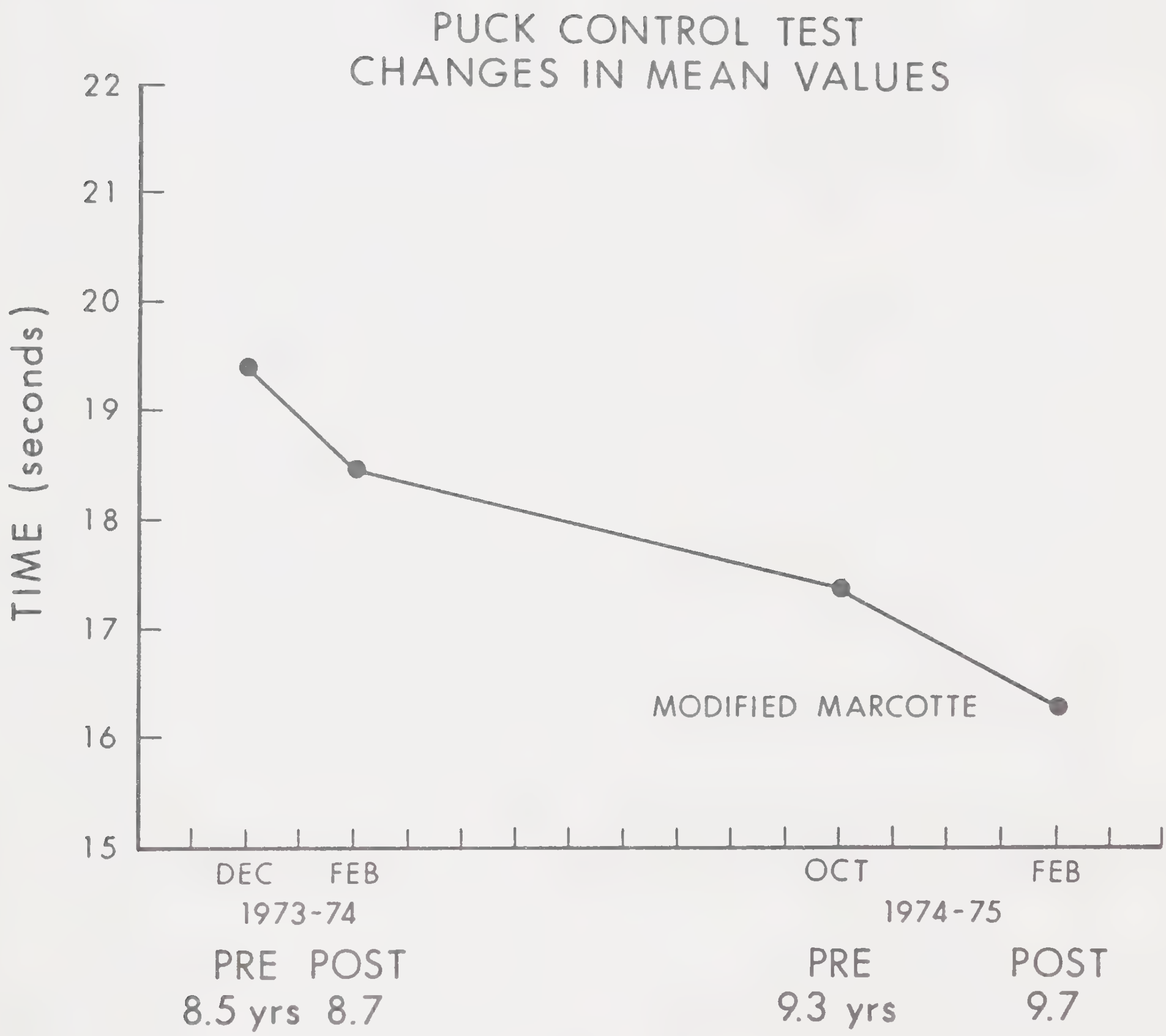
The hockey group did not participate in this test the previous year.

Macnab - Gill

This test was introduced and administered at post season. The mean time recorded was 12.5 seconds.

In general, the results of the hockey skill tests are as expected. The group improved their previous scores in every test, some to a greater extent than others depending on the nature of the test. For

FIGURE 11


PUCK CONTROL TEST
CHANGES IN MEAN VALUES
TIME (seconds)
22
21
20
19
18
17
16
15
MODIFIED MARCOTTE
DEC
FEB
1973-74
OCT
FEB
1974-75
PRE
POST
8.5 yrs
8.7
PRE
POST
9.3 yrs
9.7

instance, it was expected that the hockey group would not improve on their forward and backward linear skating drills to the same extent as they would on the puck control tests, simply due to the complex nature of the latter. Improved speed, techniques and familiarity with the puck control course would account for the greater improvement in the puck control tests. These factors would also account for the improvement in the agility skate as it requires a combination of speed, balance, and manoeuvrability (motor development).

The hockey group's progress and improvement is exemplified by comparing the results with previous measures obtained on the same skill tests, (Table XII). Thibault (39) administered the tests to the same group a year previously. He reported that a statistically significant improvement ($p < .05$) was found at the 90' distance in the backward linear skate, a significant improvement of 1.0 seconds was found between the pre and post season agility skate results and a significant improvement of 0.9 seconds was recorded for the Modified Marcotte Puck Control Test. No statistically significant improvement was recorded for the remainder of the tests. By inspection of Table XII, the previously discussed improvements and other measurable differences are apparent. The hockey group continued to improve in backward skating, agility and puck control (Mod. Marcotte). The difference between pre and post season means demonstrates this point. Also, the mean scores of the remaining tests, forward linear skate and Hansen Puck Control, improved markedly as indicated by the difference in means between pre and post season. An improvement of 3.0 seconds in the Hansen test was the most dramatic.

In comparison to the mean scores for the same age group reported

TABLE XII

COMPARED HOCKEY SKILL MEASUREMENTS

AUTHOR(S)	SEASON	AGE (YRS.)	N.	FRONT SKATE 60'	FRONT SKATE 90'	FRONT SKATE 120'	BACKWARD SKATE 60'	BACKWARD SKATE 90'	BACKWARD SKATE 120'	AGILITY	PUCK CONTROL MARCOTTE	PUCK CONTROL HANSEN
THIBAULT	PRE SEASON	8.4	14									
	MEAN			3.6	5.0	6.7	5.5	7.9	10.9	13.7	19.4	
	S.D.			0.1	0.2	0.2	0.5	0.6	0.9	0.9	1.4	
	POST SEASON	8.8	14									
	MEAN			3.6	5.0	6.5	5.4	7.7	10.2	12.7	18.5	
	S.D.			0.2	0.2	0.3	0.3	0.6	0.6	0.6	1.1	
GILL	PRE SEASON	9.3	14									
	MEAN			3.3	4.9	6.4	4.8	7.0	9.2	12.2	1.2	24.6
	S.D.			0.2	0.3	0.3	0.4	0.6	0.8	0.8	1.2	1.8
	POST SEASON	9.8	14									
	MEAN			3.2	4.5	5.8	4.5	6.2	8.1	11.3	16.3	2.16
	S.D.			0.3	0.2	0.2	0.4	0.5	0.6	0.6	0.9	1.6
HANSEN	EXPECTED TIMES	8-9			5.5			10.8		14.1	23.5	
		10-11				6.2			11.1	12.5		25.4
	SKILL TEST RESULTS											
	POST SEASON	8-9.5	33		5.7			9.8		14.1	23.2	
	POST SEASON	9.5-11	33			6.6			9.9	11.9		24.6

by Hansen (24), Table XI, the mean results of the present hockey group are better in all cases. This applies to both the mean "Expected Times" and "Skill Test Results". The same trend is apparent when the present mean results are compared to the next highest age category reported by Hansen.

The results of the present investigation clearly substantiate the facts that the hockey team, individually and on a team basis, improved considerably in their hockey skill performance over the duration of one year and secondly, when compared to other hockey players of the same age they are superior. This improvement may be attributed to a variety of factors. Clearly, age and growth (maturity) play a predominant role in their improvement. One year of growth combined with learning and skill practice over the same period contributed immensely. Also, the improvement may in part be attributed to the difference in the physical testing facilities employed; Thibault (39) conducted the tests on an outdoor arena and the present tests were administered indoors. Another contributing factor would be the familiarity of the tests. Over the period of a year and four months, these subjects have repeated the tests on four occasions.

Physical Work Capacity

Post season individual scores for both groups are presented in Appendix G. Means and standard deviations are reported in Table XIII. Also, Table XIV contains a comparison of post season means for both groups compiled over the duration of a year. Figure 12 and 13 represent the changes in mean values over the period of fifteen months. The physical work capacity results are reported in kilopound meters per minute (kpm/min) (Fig. 12) and in terms of body weight (kg/body weight) (Fig. 13).

TABLE XIII

PHYSICAL WORK CAPACITY

POST SEASON (1975) MEANS AND STANDARD DEVIATIONS

GROUP		PWC 170 KPM/MIN	BODY WEIGHT (KG)	PWC 170/KG	*ESTIMATED LITRES/MIN	MVO_2 ML/KG/MIN
CONTROL	11					
MEAN		488	30.5	16.00	1.76	58.95
S.D.		110.15	4.77	3.40	0.27	10.03
HOCKEY	14					
MEAN		456	30.8	15.02	1.72	56.99
S.D.		26.61	4.12	1.85	0.10	8.17

* VO_2 in litres corrected for age.

TABLE XIV

PHYSICAL WORK CAPACITY

COMPARED POST SEASON MEANS AND STANDARD DEVIATIONS

YEAR	N		PHYSICAL WORK CAPACITY KPM/MIN	PHYSICAL WORK CAPACITY KG/BODY WEIGHT
1973-74	(C)*	11	411 ± 65.51	15.18 ± 1.88
	(H)	14	433 ± 58.36	15.49 ± 2.37
1974-75	(C)	11	488 ±110.15	16.00 ± 3.40
	(H)	14	456 ± 26.61	15.02 ± 1.85

* Mean score of 11 subjects who repeated PWC 170 test

FIGURE 12

PHYSICAL WORK CAPACITY
CHANGES IN MEAN VALUES

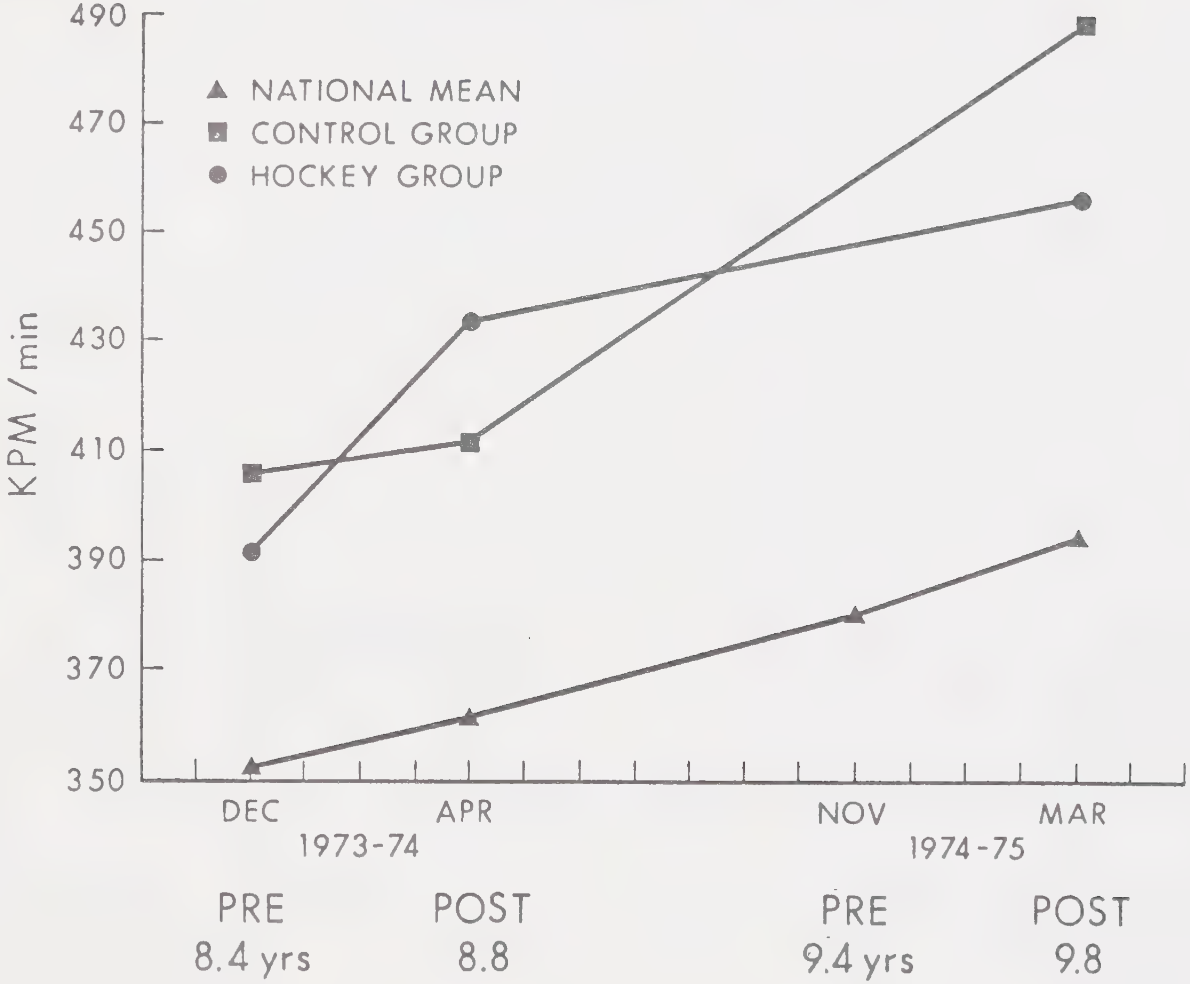
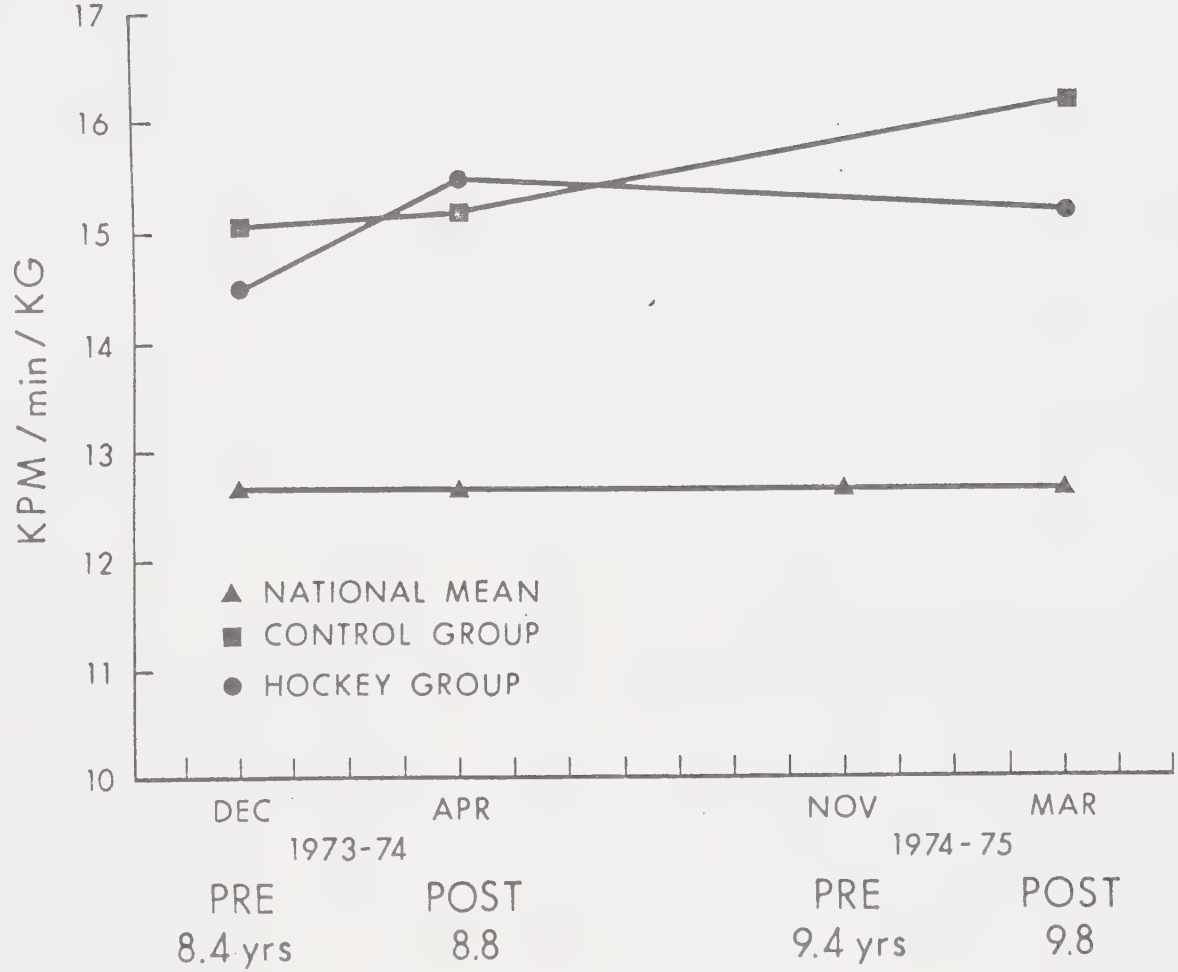


FIGURE 13

PHYSICAL WORK CAPACITY
CHANGES IN MEAN VALUES



The mean post season 1975 physical work capacity value for the control group was 488 kpm/min (Table XIII), an increase of 77 kpm/min (18.76%) compared to the previous post season mean score (Table XIV). For the same group, the mean post season score, when expressed in terms of body weight, was 16.00 kg/body weight, which represents an average increase of .82 kg/body weight (5.4%) over a period of one year. The mean post season 1975 physical work capacity value for the hockey group is 456 kpm/min.; an increase of 23 kpm/min. (5.3%) compared to the previous post season mean. Relative to body weight, the post season mean score for the hockey group is 15.02 kg/body weight. This value represents a decline of 0.47 kg/body weight (-3.0%) from the previous post season mean score of 15.49 kg/body weight.

The observed difference between group means at post season 1975 is 32 kpm/min. and .98 kg/body weight.

The results of the physical work capacity data are explicit. It was quite apparent that both the control and experimental groups improved their respective mean PWC 170 values. The former group increased from 411 to 488 kpm/min. and the latter showed an improvement from 433 to 456 kpm/min. over the duration of one year. This trend is supported by numerous other investigations. The authors of previous studies (2, 3, 4, 5, 6, 9, 14, 15, 25, 30, 33) concluded that there is a concurrent increment in physical work capacity with increasing age. More specifically, this increment appears to begin in the latter stages of pre-adolescence (8 to 11 years), magnifies during adolescence and peaks at post adolescence. The authors of the aforementioned studies have also indicated that physical work capacity, when expressed as PWC 170 kg/body weight, appears to follow another trend. Results of

these investigations showed that PWC 170 kg/body weight remains fairly constant throughout the entire age range of 8 to 18 years. This observation was exmplified in the present investigation; as both the control and hockey groups respective mean PWC 170 kg/body weight remained relatively stable. The mean value of the hockey group showed a very slight decline from 15.49 to 15.02 over the period of a year. On the other hand, their counterparts showed an average mean increment of .82 kg/body weight over the same period of time. This trend may in part be attributed to the fact that an increase in PWC 170 kpm/min. was also accompanied by an increase in body weight with age. Consequently, changes in physical work capacity expressed in terms of body weight, are relative and proportional to changes in body weight. In the present example, both groups had the same mean body weight at post season 1974 and over the period of a year displayed virtually the same body weight gain. This would explain the fact that no change or very little change was observed in their respective PWC 170 kg/body weight mean scores. Thus, the rate of change in PWC 170 kg/body weight was proportional to the rate of change in body weight.

To the author's knowledge, the extent to which PWC 170 values vary over a period of time has received limited attention in the literature. However, a few studies have been made to ascertain the influence of varying periods of time on physical work capacity. Cummings (15) and Baggley (9) investigated the affect of seasonal variations on the physical working capacities of normal school children in Winnipeg, Canada. They both concluded and reported that in the absence of a determined effort at physical training, normal physical

summer and winter activities are insufficient to improve PWC 170 in normal children. Adams (3) lent support to this observation as indicated in his evaluation of PWC 170 scores of Stockholm children over the period of four months summer vacation. The results of Thibault's (39) investigation revealed virtually the same results as the control group failed to show a significant improvement in PWC 170 over the duration of four months. Contrary to this, Alderman (5) revealed that rural children, aged 10 and 14 years, improved their respective PWC 170 scores over the duration of one year. The results of the present investigation support the results described by Alderman (3). Both the control and hockey groups improved their respective mean PWC 170 values, especially the control group who showed an increment of 18.7% over the year. The periods of time employed in these investigations may account for the discrepancy in obtained results.

Cumming (17) suggested that the lack of improvement in the aerobic capacity of male and female athletes participating in an intensive track and field program may in fact be attributed to the initial fitness levels of the athletes prior to the training session. This explanation may also account in part for the fact that the control group, who had a lower initial fitness level than the hockey group, improved more dramatically. A reduction in the resting heart rate as a result of training may account for the increased PWC 170 of the hockey group.

Another possible explanation may in part be attributed to the nature of the physical activities engaged in by the subjects of the present investigation. In particular, as expressed previously, the members of the present control group appeared to be more involved and

active in various sporting activities over the duration of time between testing sessions; three subjects participated in a low-keyed community hockey league and approximately half a dozen others played community basketball and/or floor hockey over the winter months. These activities, with the exception of hockey, are considered to be aerobic in nature; long duration and low intensity, which would have a more pronounced influence on the subject's aerobic or physical work capacity. On the other hand, the physiological nature of hockey is considered to be anaerobic; high intensity and short duration. Consequently, the influence of a season of ice hockey would in all probability enhance their anaerobic capacities rather than their aerobic capacities.

The format of the present investigation lends itself to be compared to measures obtained from normative studies (3, 4, 6, 14, 15, 25, 30). These comparisons will afford the opportunity to observe the differences, if any, of the functional fitness levels between the present group of boys and other boys of the same age.

Keeping in mind the limitations which are inherent in comparing PWC 170 results, some comparisons of PWC 170 results are presented in Table XV. In considering these results, it should be emphasized that numerous variations exist in the methodology and procedures employed in arriving at these results.

In absolute terms, the physical work capacity results from the present study are roughly comparable to the Prague, Winnipeg (Cumming and Cumming), Norway data, somewhat above the data present from Winnipeg (Cumming and Danzinger), Canada, somewhat below those of Los Angeles and considerably below the Sweden data. A comparison is also given of height and body weight of the samples involved. The Los

TABLE XV

COMPARED PHYSICAL WORK CAPACITY MEASUREMENTS

AUTHOR(S)	CITY	SEX	AGE (YRS)	N	HEIGHT (INS)	WEIGHT (KG)	PHYSICAL WORK CAPACITY KPM/MIN	PHYSICAL WORK CAPACITY KG/BODY WEIGHT
ADAMS (I)	Los Angeles (California)	M	9	10 10	55.1	35	472	13.48
ADAMS (II)	Stockholm (Sweden)	M	10	12	56.7	35	490	13.61
	Sweden Country Side	M	10	13	54.7	33	510	15.43
		M	8	29	51.5	27	392	14.51
ANDRESEN (I)	Lom (Norway)	M	10	14	56.2	33	464	14.06
CUMMING AND CUMMING	Winnipeg (Canada)	M	9	5	54.7	34	435	12.79
CUMMING AND DANZINGER	Winnipeg (Canada)	M	10	19	55.1	39.6	411	10.39
HOWELL AND MACNAB	Canada	M	9	119	--	30	385	12.83
			10	101	--	33	427	12.93
		M	8	8	51.2	27	378	14.00
MACEK	Prague	M	10	8	54.3	32	451	14.09
THIBAULT	Edmonton	M	8	11(C)	51.5	27.2	411	15.18
		M	8	14(H)	52.7	28.1	433	15.49
GILL	Edmonton	M	9.8	11(C)	53.5	30.5	488	11.00
			9.6	14(H)	54.4	30.8	456	15.02

* Above data reported on non-athletic, normal school aged children, except THIBAULT (H) and GILL (H).

Angeles, Stockholm, and Winnipeg (Cumming and Danzinger) samples are consistently heavier than any other groups, particularly the present sample. This observation raises the possibility that the apparent superiority of the Los Angeles and Swedish children in PWC 170 may in part be attributed to their greater size. Expressing the data in terms of body weight appears to exemplify this observation, that indeed the present results, and those of Prague and Norway, surpass those of Los Angeles and Sweden.

Thus, if one chose to ignore the inherent limitations in relative PWC 170 comparison, it may be concluded that when expressed in relative terms (PWC 170 kg/body weight), the groups of the present investigation are ranked the highest in relation to the other groups.

SUMMARY AND CONCLUSIONS

The physical fitness levels of two groups of nine year old boys was measured over the duration of four months to observe the influence of participating in a competitive hockey season. A group of fourteen hockey players was compared to a group of eleven non-hockey players. Measurements on anthropometric parameters, grip strength, fitness performance items and physical work capacity are compiled and evaluated for both groups. In addition, the hockey group completed a battery of hockey skill items.

The following results were observed with regards to anthropometric measures. The mean age of the hockey group was 2.1 months greater than that of the control group at post season. Mean height and weight differences at post season favored the hockey group, however, the difference of means over the period of one year revealed that the control improved at a slightly faster rate. The mean height and weight measures improved 2.0 inches and 6.3 pounds for the control group compared to 1.7 inches and 5.7 pounds for the hockey group. Bi-iliac and bi-acromial mean measurements are greater for the hockey group. They also appeared to improve slightly more over a year than for the control group.

Mean post season grip strength, left and right, values are greater for the hockey group, however, the difference of means between testing periods suggest that the control group improved at a faster rate.

Both groups, control and hockey, improved their respective mean scores on each of the CAHPER Performance Items. The hockey group post season scores are greater than the mean control group scores for every

skill test. However, over the duration of one year, the difference in means between testing periods indicated that the control group improved more on three items; in particular the 300 yard run, flexed arm hang and standing broad jump, and the hockey group improved on the 50 yard dash and speed sit-ups. Both groups appeared to improve at the same rate on the shuttle run course.

As expected, the hockey group improved their performance on the battery of hockey skill items over the duration of four months and one year. Over the four months, the most pronounced improvements occured over the "acceleration phase" in the forward linear skate, over the "speed phase" in the backward skate and in the puck control tests, particularly the Hansen test. The improvement in the agility skate was not as conspicuous as the other reported increments.

The physical work capacity mean scores improved for both groups over the duration of one year. The control group mean improved from 411 to 488 kpm/min. and the hockey group mean increased from 433 to 456 kpm/min. However, the post season mean score for the control group was greater than that of the hockey group and also showed a faster rate of improvement as indicated by the difference of means between testing periods. The same trend was apparent when these mean scores are reported relative to body weight. The control group's post season mean PWC 170 value, when expressed in terms of body weight, was greater than the hockey groups; 16.00 kg/body weight compared to 15.02 kg/body weight for the latter.

In conclusion, it would appear that the influence of active participation in a competitive season of ice hockey was most pronounced in the CAHPER Fitness - Performance Items, grip strength and the hockey

skills items. In spite of the fact that the hockey group post season means are superior to those of the control groups in every item, except the PWC 170 mean values, the control group showed an overall greater rate of improvement over the duration of one year.

These results would seem to suggest that the influence of participating in a highly competitive organized sport, such as hockey, contributes to specific parameters of fitness, rather than having a significant influence on the aerobic capacities.

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APPENDIX A

CALIBRATION TABLE FOR THE BICYCLE ERGOMETER

CALIBRATION TABLE FOR THE BICYCLE ERGOMETER

KP SETTING	CALIBRATION A*
0.5	.220
1.0	.415
1.5	.650
2.0	.870
2.5	1.080
3.0	1.290
3.5	1.540
4.0	1.745
4.5	1.960
5.0	2.250
5.5	2.440
6.0	2.650
6.5	2.870
7.0	3.070

N.B. In all PWC 170 tests a small modified pendulum was employed as described by Howell and Macnab (23)

*ACTUAL KP - represents the number of grams required to raise the pendulum to successive scale markings.

APPENDIX B

NAMES OF SUBJECTS, IDENTIFICATION NUMBERS, AND DATES OF BIRTH

SUBJECTS

CONTROL GROUP

NAME	*I.D.#	DATE OF BIRTH (DAY) (MON.) (YR)
BELLOW, J.	1	19 - 07 - 65
COLVIN, T.	4	18 - 09 - 65
DELVIN, J.	5	17 - 07 - 65
GYNANE, S.	6	01 - 04 - 65
HALL, G.	7	03 - 01 - 66
McLEOD, S.	8	22 - 09 - 65
McPHERSON, K.	9	21 - 06 - 65
MISSOURI, D.	10	08 - 10 - 65
MITTAL, P.	11	13 - 05 - 65
OOSTERHUIS, E.	12	31 - 08 - 65
SZASZKIEWICZ, P.	13	30 - 10 - 65

*I.D.# - Identification numbers correspond to the numbering scheme employed by Thibault (40).

SUBJECTS

HOCKEY GROUP

NAME	*I.D.#	DATE OF BIRTH (DAY) (MON.) (YR)
ANTONIUK, M.	15	12 - 01 - 65
CARLSON, R.	16	11 - 06 - 65
DONADT, R.	17	26 - 03 - 65
DONALD, S.	18	24 - 06 - 65
HOLGATE, B.	19	06 - 12 - 65
JONES, B.	20	06 - 09 - 65
LEISEN, B.	21	03 - 07 - 65
LUND, G.	22	12 - 07 - 65
LUND, T.	23	12 - 07 - 65
MACNAB, B.	24	16 - 07 - 65
MILLIGAN, P.	25	21 - 04 - 65
ROBERGE, D.	26	15 - 02 - 65
TKACKUK, S.	27	25 - 02 - 65
WOZNIAK, L.	28	03 - 09 - 65

*I.D.# - Identification numbers correspond to the numbering scheme employed by Thibault (40).

APPENDIX C

ANTHROPOMETRIC MEASURES

(RAW SCORES)

ANTHROPOMETRIC MEASURES

CONTROL GROUP

(POST SEASON 1975)

NO.	AGE (MONS.)	HEIGHT (INS.)	WEIGHT (LBS.)	BI-ILIAC (CM)	BI-ACROMIAL (CM)
1	117	58.00	75.00	21.0	30.8
4	115	49.50	49.25	18.0	27.0
5	117	57.00	74.00	23.0	28.0
6	120	56.25	75.75	20.8	29.8
7	111	50.75	58.25	20.5	29.0
8	115	53.75	62.50	21.0	28.7
9	118	55.00	71.25	20.5	31.3
10	114	50.75	59.25	20.7	28.0
11	119	51.75	57.00	19.0	29.0
12	116	54.00	72.50	21.8	29.0
13	114	51.75	73.00	20.5	28.4
MEAN	116	53.5	66.2	20.6	28.1
S.D.	2.6	2.87	9.15	1.3	3.0

ANTHROPOMETRIC MEASURES

HOCKEY GROUP

(POST SEASON 1975)

NO.	AGE (MONS.)	HEIGHT (INS.)	WEIGHT (LBS.)	BI-ILIAC (CM)	BI-ACROMIAL (CM)
15	123	57.50	86.00	22.7	28.5
16	118	54.25	65.00	20.9	30.1
17	121	54.00	66.75	22.5	30.0
18	118	57.00	81.00	23.2	32.2
19	112	54.50	61.00	21.0	28.8
20	115	54.50	68.00	20.5	30.0
21	117	57.75	83.00	22.8	29.8
22	117	53.50	60.00	21.0	30.5
23	117	52.75	56.25	20.7	29.5
24	117	53.25	61.75	21.0	29.0
25	120	53.00	63.00	20.0	28.0
26	122	53.00	64.00	22.2	29.3
27	122	51.75	65.50	20.0	28.6
28	115	54.25	67.00	20.3	30.4
MEAN	118.1	54.4	67.7	21.3	29.6
S.D.	3.13	1.83	9.05	1.10	1.06

ANTHROPOMETRIC MEASURES

HOCKEY GROUP

(POST SEASON 1975)

NO.	AGE (MONS.)	HEIGHT (INS.)	WEIGHT (LBS.)	BI-ILIAC (CM)	BI-ACROMIAL (CM)
15	123	57.50	86.00	22.7	28.5
16	118	54.25	65.00	20.9	30.1
17	121	54.00	66.75	22.5	30.0
18	118	57.00	81.00	23.2	32.2
19	112	54.50	61.00	21.0	28.8
20	115	54.50	68.00	20.5	30.0
21	117	57.75	83.00	22.8	29.8
22	117	53.50	60.00	21.0	30.5
23	117	52.75	56.25	20.7	29.5
24	117	53.25	61.75	21.0	29.0
25	120	53.00	63.00	20.0	28.0
26	122	53.00	64.00	22.2	29.3
27	122	51.75	65.50	20.0	28.6
28	115	54.25	67.00	20.3	30.4
MEANS	118.1	54.4	67.7	21.3	29.6
S.D.	3.13	1.83	9.05	1.10	1.06

APPENDIX D

GRIP STRENGTH MEASURES

(RAW SCORES)

GRIP STRENGTH

CONTROL GROUP

(POST SEASON 1975)

NO.	LEFT GRIP (LBS.)	RIGHT GRIP (LBS.)
1	39.6	49.5
4	28.6	37.4
5	50.6	52.8
6	57.2	59.4
7	28.6	35.2
8	36.3	46.2
9	57.2	55.0
10	38.5	31.9
11	37.4	38.5
12	42.9	45.1
13	44.0	48.4
MEAN	41.9	45.4
S.D.	9.9	8.8

GRIP STRENGTH

HOCKEY GROUP

(POST SEASON 1975)

NO.	LEFT GRIP (LBS.)	RIGHT GRIP (LBS.)
15	63.8	66.0
16	45.1	44.0
17	39.6	49.5
18	52.8	57.2
19	42.9	42.9
20	38.5	41.8
21	50.6	50.6
22	34.1	37.4
23	34.1	35.2
24	41.8	48.4
25	37.4	33.0
26	35.2	39.6
27	48.4	48.4
28	55.0	57.2
MEAN	44.2	46.5
S.D.	8.8	9.29

APPENDIX E

CAHPER FITNESS - PERFORMANCE ITEMS

(RAW SCORES)

C.A.H.P.E.R. FITNESS PERFORMANCE ITEMS

CONTROL GROUP

(POST SEASON 1975)

NO.	SPEED SIT-UPS (NO.)	STD. BROAD JUMP (INCHES)	SHUTTLE RUN (SECS.)	FL. ARM HANG (SECS.)	50 YD. DASH (SECS.)	300 YD. RUN (SECS.)
1	28	67.0	14.1	25.0	9.0	69.0
4	24	49.0	13.0	48.5	9.0	73.0
5	35	64.0	12.3	73.0	8.7	65.0
6	32	64.0	12.9	71.0	8.4	67.0
7	38	54.5	11.9	28.5	8.4	65.0
8	34	62.0	11.4	71.0	8.2	64.0
9	24	57.0	13.9	88.0	8.8	72.0
10	32	50.0	13.2	47.0	8.6	67.0
11	27	56.0	11.6	39.0	8.4	68.0
12	40	57.0	74.0	74.0	8.6	65.0
13	26	59.0	12.0	24.0	8.4	67.0
MEAN	30.9	58.2	12.7	53.5	8.6	67.5
S.D.	5.5	5.8	0.9	22.7	0.3	2.9

C.A.H.P.E.R. FITNESS PERFORMANCE ITEMS

HOCKEY GROUP

(POST SEASON 1975)

NO.	SPEED SIT-UPS (NO.)	STD. BROAD JUMP (INCHES)	SHUTTLE RUN (SECS.)	FL. ARM HANG (SECS.)	50 YD. DASH (SECS.)	300 YD. RUN (SECS.)
15	45	63.0	12.3	75	8.9	64.0
16	35	57.0	11.6	133	8.0	62.5
17	42	70.0	11.0	70	8.4	63.5
18	33	56.0	11.9	87	7.9	62.5
19	32	64.0	11.8	74	8.0	66.0
20	44	59.0	12.5	46	7.9	67.0
21	30	60.0	12.4	62	9.3	66.0
22	46	57.5	11.4	105	8.3	66.0
23	45	56.5	11.1	111	8.7	65.5
24	47	64.5	12.0	99	7.9	64.0
25	31	52.0	12.3	47	8.0	68.0
26	46	69.0	11.0	59.5	7.9	63.0
27	41	64.0	11.8	133.5	8.5	65.0
28	42	58.0	12.2	22	8.8	68.0
MEAN	39.9	60.8	11.8	80.3	8.3	65.1
S.D.	6.3	5.2	0.5	33.0	0.4	1.9

C.A.H.P.E.R. FITNESS PERFORMANCE ITEMS

CONTROL GROUP

NO.	50 YARD POST(74)	50 YARD POST(75)*	300 YARD POST(74)	300 YARD POST(75)*	SHUTTLE RUN POST(74)	SHUTTLE RUN POST(75)	FLEX ARM H. POST(74)	FLEX ARM H. POST(75)	STD. LONG JUMP POST(74)	STD. LONG JUMP POST(75)**	SPEED SIT-UPS POST(74)	SPEED SIT-UPS POST(75)
1	9.4	9.0	71.7	69	15.1	14.1	19	25	58.3	67.0	27	28
4	9.5	9.0	74.5	73	13.2	13.0	11	48.5	42.3	49.0	19	24
5	9.5	8.7	72.0	65	13.6	12.3	27	73	55.8	64.0	19	35
6	8.8	8.9	68.6	67	12.7	12.9	21	71	56.0	64.0	27	32
7	8.4	8.4	65.8	65	11.5	11.9	29	28.5	48.5	54.5	22	38
8	8.7	8.2	73.1	64	11.8	11.4	28	71	58.0	62.0	37	34
9	9.3	8.8	73.8	72	13.6	13.9	20	88	50.0	57	18	24
10	9.2	8.6	73.8	67	13.0	13.2	19	47	44.3	50	17	32
11	8.8	8.4	69.4	68	11.6	11.6	12	39	48.0	56	26	27
12	8.5	8.6	69.7	65	12.8	13.3	11	74	51.5	57	35	40
13	8.7	8.4	76.1	67	11.7	12.0	15	24	52.8	59.5	20	26
MEAN	8.9	8.6	71.7	67.5	12.8	12.7	19.3	53.5	51.4	58.2	24.3	30.9
S.D.	0.4	0.3	3.0	2.9	1.1	0.9	6.6	22.7	5.4	5.8	6.8	5.5

* Recorded to the nearest second.

** Recorded to the nearest inch.

C.A.H.P.E.R. FITNESS PERFORMANCE ITEMS

HOCKEY GROUP

NO.	50 YARD		300 YARD		SHUTTLE RUN		FLEX ARM H.		STD. LONG JUMP		SPEED SIT-UPS	
	POST(74)	POST(75)*	POST(74)	POST(75)*	POST(74)	POST(75)	POST(74)	POST(75)	POST(74)	POST(75)**	POST(74)	POST(75)
15	9.0	8.9	65.5	64.0	12.2	12.3	63	75	58.15	63.0	26	45
16	8.6	8.0	65.5	62.5	11.9	11.6	60	133	59.50	57.0	29	35
17	8.5	8.4	65.5	63.5	11.4	11.0	61	70	52.25	70.0	36	42
18	8.4	7.9	66.0	62.5	11.5	11.9	64	87	56.60	56.0	17	33
19	8.8	8.0	66.4	66.0	12.4	11.8	80	74	56.15	64.0	22	32
20	8.5	7.9	70.0	67.0	12.4	12.5	25	46	49.75	59.0	26	44
21	8.8	9.3	71.5	66.0	11.6	12.4	33	62	58.00	60.0	29	30
22	8.9	8.3	71.5	66.0	11.8	11.4	74	105	60.00	57.5	35	46
23	9.0	8.7	71.0	65.5	11.2	11.1	68	111	60.25	56.5	39	45
24	9.8	7.9	66.0	64.0	12.8	12.0	72	99	54.00	64.5	39	47
25	10.5	8.0	73.0	68.0	11.8	12.3	13	47	48.50	52.0	10	31
26	8.3	7.9	65.4	63.0	11.4	11.0	60	59.5	62.80	69.0	42	46
27	8.9	8.5	74.0	65.0	11.6	11.8	75	133.5	53.75	64.0	31	41
28	8.9	8.8	67.5	68.0	11.2	12.2	60	22	50.15	58.0	40	42
MEAN	8.9	8.3	68.5	65.1	11.8	11.8	57.7	80.3	55.70	60.75	30.0	39.9
S.D.	0.5	0.4	3.0	1.9	0.5	0.5	19.1	33.0	4.25	5.16	9.0	6.3

APPENDIX F

HOCKEY SKILL TESTS

(RAW SCORES)

HOCKEY SKILL ITEMS (1974 - 1975)

NO.		FRONT SKATE 60'	90'	120'	BACK SKATE 60'	90'	120'	AGILITY	MARCOTTE	HANSEN	MACNAB-GILL
15	PRE	3.0	4.6	6.1	4.2	6.3	8.2	11.3	15.5	22.9	
	POST	3.2	4.3	5.7	4.0	5.5	7.3	11.2	16.6	19.9	11.4
16	PRE	3.5	5.2	6.8	5.0	7.1	9.5	12.2	18.1	24.0	
	POST	3.4	4.6	6.0	4.6	6.2	8.2	10.9	16.7	20.5	11.6
17	PRE	3.5	5.2	6.5	4.7	6.9	9.2	11.9	17.3	22.5	
	POST	3.1	4.2	5.5	4.3	6.0	8.0	10.9	15.1	19.4	12.0
18	PRE	3.1	4.7	6.6	4.9	7.2	9.2	13.3	17.7	26.2	
	POST	3.1	4.5	5.8	4.8	6.7	8.6	11.6	16.1	24.3	12.8
19	PRE	3.3	5.3	6.6	5.0	7.2	9.6	12.6	18.5	23.9	
	POST	3.1	4.4	5.8	4.2	5.4	7.7	11.5	16.0	22.3	12.9
20	PRE	3.3	4.7	6.3	5.4	8.1	10.4	12.9	19.4	27.9	
	POST	3.0	4.3	5.6	5.2	7.0	9.0	12.1	17.1	23.7	14.9
21	PRE	3.2	5.5	6.7	4.5	6.4	8.7	11.3	16.7	22.4	
	POST	3.1	4.5	5.7	4.5	6.2	8.1	11.2	16.6	20.3	12.5
22	PRE	3.2	4.8	6.2	4.6	7.0	9.3	13.0	17.0	25.1	
	POST	3.4	4.5	5.9	4.7	6.5	8.4	11.0	15.7	20.4	12.7
23	PRE	3.5	5.1	6.7	4.5	6.7	8.7	12.5	17.3	24.8	
	POST	3.3	4.7	6.2	4.2	6.0	7.7	11.0	16.4	20.5	11.5
24	PRE	3.2	4.7	6.3	5.1	7.6	9.9	11.4	15.4	23.5	
	POST	3.1	4.3	5.8	4.6	6.3	8.3	10.8	14.9	22.4	11.4
25	PRE	3.5	4.9	6.6	5.0	7.5	9.9	13.2	17.2	25.9	
	POST	3.6	4.7	5.9	4.9	7.0	8.9	11.7	18.0	22.3	13.9
26	PRE	3.1	4.8	6.0	4.5	6.5	8.5	11.9	16.7	25.5	
	POST	3.2	4.6	5.7	4.1	5.8	7.4	10.8	15.7	22.0	12.1
27	PRE	3.1	4.8	6.2	4.2	5.9	7.8	10.8	17.0	22.9	
	POST	3.1	4.4	5.7	4.2	5.9	7.6	10.6	15.8	20.7	11.9
28	PRE	3.3	5.2	6.6	4.6	5.9	9.7	12.4	19.4	27.4	
	POST	3.2	4.5	5.8	4.4	6.3	8.3	12.4	18.1	23.8	13.3
MEAN	PRE	3.3	4.9	6.4	4.8	7.0	9.2	12.2	17.4	24.6	
	POST	3.2	4.5	5.8	4.5	6.2	8.1	11.3	16.3	21.6	12.5

APPENDIX G

PHYSICAL WORK CAPACITY

(RAW SCORES)

PHYSICAL WORK CAPACITY

CONTROL GROUP

(POST SEASON 1975)

NO.	PWC 170 (KPM/MIN.)	BODY WEIGHT (KG)	PWC 170 KG/BODY WEIGHT
1	480	38.6	12.43
4	297	22.4	13.29
5	422	33.6	12.54
6	461	34.4	13.39
7	415	26.6	15.61
8	531	28.4	18.71
9	509	32.4	15.72
10	552	26.9	20.52
11	459	25.9	18.36
12	497	32.9	15.08
13	747	33.2	22.52
MEAN	488	30.5	16.20
S.D.	110.15	4.77	3.40

PHYSICAL WORK CAPACITY

HOCKEY GROUP

(POST SEASON 1975)

NO.	PWC 170 (KPM/MIN.)	BODY WEIGHT (KG)	PWC 170 KG/BODY WEIGHT
15	520	39.1	13.29
16	453	29.5	15.33
17	440	30.3	14.49
18	479	36.8	13.00
19	425	27.6	15.39
20	436	30.9	14.12
21	437	37.7	11.59
22	475	27.2	17.42
23	487	25.6	19.04
24	457	28.1	16.28
25	450	28.6	15.72
26	422	29.1	14.50
27	448	29.7	15.05
28	460	30.5	15.12
MEAN	456	30.8	15.02
S.D.	26.6	4.12	4.12

PHYSICAL WORK CAPACITY

CONTROL GROUP

(POST SEASON 1975)

SUBJECTS	NO.	PWC 170 KPM/MIN	BODY WEIGHT (KG)	PWC 170/KG	*ESTIMATED L/MIN	MVO_2 ML/KG/MIN
BELLOW, J.	1	480	38.6	12.43	1.69	43.77
COLVIN, T.	4	297	22.4	13.29	1.32	59.06
DELVIN, J.	5	422	33.6	12.54	1.59	47.44
GYNANE, S.	6	461	34.4	13.39	1.61	46.67
HALLS, G.	7	415	26.6	15.61	1.69	63.60
McLEOD, S.	8	531	28.4	18.71	1.79	62.98
McPHERSON, K.	9	509	32.4	15.72	1.77	54.78
MISSOURI, D.	10	552	26.9	20.52	1.96	72.84
MITTAL, P.	11	459	25.9	18.36	1.69	67.73
OOSTERHUIS, E.	12	497	32.9	15.08	1.90	57.73
SZASZKIEWICZ, P.	13	747	33.2	22.52	2.38	71.84
MEAN		488	30.5	16.80	1.76	58.95
S.D.		110.15	4.77	3.40	0.27	10.03

* VO_2 in litres corrected for age.

PHYSICAL WORK CAPACITY

HOCKEY GROUP

(POST SEASON 1975)

SUBJECTS	NO.	PWC 170 KPM/MIN	BODY WEIGHT (KG)	PWC 170/KG	*ESTIMATED L/MIN	MVO_2 ML/KG/MIN
ANTONIUK, M.	15	520	39.1	13.29	1.88	48.32
CARLSON, R.	16	453	29.5	15.33	1.66	56.13
DONADT, R.	17	440	30.3	14.49	1.63	53.91
DONALD, S.	18	479	36.8	13.00	1.82	49.56
HOLGATE, B.	19	425	27.6	15.39	1.65	59.82
JONES, B.	20	436	30.9	14.12	1.63	52.69
LEISEN, B.	21	437	37.7	11.59	1.56	41.28
LUND, G.	22	475	27.3	17.42	1.82	66.90
LUND, T.	23	487	25.6	19.04	1.89	74.16
MACNAB, B.	24	457	28.1	16.28	1.81	64.38
MILLIGAN, P.	25	450	28.6	15.72	1.69	59.16
ROBERGE, D.	26	422	29.1	14.50	1.69	58.22
TKACHUK, S.	27	448	29.8	15.05	1.67	55.97
WOZNIAK, L.	28	460	30.5	15.12	1.75	57.49
MEAN		456	30.8	15.02	1.73	56.99
S.D.		26.61	4.12	1.85	0.10	8.17

* VO_2 in litres corrected for age.

APPENDIX H

COMPUTER PROGRAM

COMPUTER PROGRAM:

PWC AND ESTIMATED MVO_2 VALUES

```
      WCT ( )
      WCT
( 1)  N pHR
( 2)  SC +/HR
( 3)  WL PR 6 KP
( 4)  SY +/WL
( 5)  6
( 6)  SXSY SX SY
( 7)  SXS +/ (HR*2)
( 8)  SYSY +/ (HR WL)
( 9)  BX (XYXY-(SXSY N))
(10)  BYX BX (SXS-((SX*2) N))
(11)  AYX (SY-(BYX SX)) N
(12)  PWF (BYX 1 50)+AYX
(13)  PWS (BYX 170)+AYX
(14)  PWZ (BYX 135)+AYX
(15)  PWB BYX 165)+AYX
(16)  (S=2)/26
(17)  VOL (0.003 PWF)+0.5
(18)  (VOL 3.7)/22
(19)  (VOL 4.7)/24
(20)  VOL VOL+0.1
(21)  25
(22)  VOL VOL+0
(23)  25
(24)  VOL VOL+0.2
(25)  27
(26)  VOL (0.00334 PWF) 0.5
(27)  ACF 1.2-(0.00913 AG)
(28)  CVL VOL ACF
(29)  VMK (CVL KG) 1000
(30)  "SUBJECTS ID IS"; ID
(31)  "PWC 150 IS"; PWF
(32)  "PWC 170 IS"; PWS
(33)  "PWC 135 IS"; PWA
(34)  "PWC 165 IS"; PWB
(35)  "PWC 170/KG IS"; PWS KG
(36)  "VO2 IN LIT IS"; VOL
(37)  "AGE FACTOR IS"; ACF
(38)  "VO2 IN LIT COR FOR AGE IS"; CUL
(39)  "VO2 IN ML/KG/MIN IS"; VMK
```

APPENDIX I

A DESCRIPTION OF THE CAHPER

FITNESS - PERFORMANCE TEST ITEMS

THE C.A.H.P.E.R. FITNESS - PERFORMANCE TEST

This test battery is the first National Fitness constructed by and conducted with Canadians. The Research Committee of the Canadian Association for Health, Physical Education, and Recreation devised this major National research project. A representative sample of Canadian boys and girls in the seven to seventeen year age range was selected and tested on the C.A.H.P.E.R. six item test battery. Data from 9,500 subjects has been processed and normative tables devised for each age group and set.

The following is a description of the Fitness - Performance Items as presented by Cummings and Keynes (17).

TEST ITEMS	DESCRIPTION
1. Speed Sit-ups	The subject assumes a back lying position on a gym mat, hands interlaced behind the head. The knees are bent and the feet are held flat on the floor by a partner. The subject sits up and touches both elbows to both knees, and then returns to the starting position. The movement of sit-up and return is counted as one execution. The total score is the number of complete executions performed in 60 seconds. One trial is allowed.
2. The Standing Broad Jump	The subject assumes a position with the feet slightly apart and the toes behind the jumping line. Flexing at the hips, knees and ankles, and using the arms as an aid, the subject jumps as far forward as possible. The measurement is in terms of inches to the nearest inch from the take-off line to the heel of the foot nearest to the take-off line. Suggested take-off angles should be between 30 and 45 degrees.

Two valid trials are allowed, the better trial being recorded. If any part of the body touches behind the heels, the jump is considered invalid and a repeat trial allowed.

3. The Shuttle Run

Lying face down, hands at the sides of the chest, and forehead on a starting line, wearing gym shoes, the subject, on signal, jumps to his feet and runs 30 feet to a second line. Two blocks of wood are placed on this line and the subject is required to pick up one block of wood, return to the starting line, and place this block behind the starting line. He must then return to the second line, pick up the second block of wood, and run back to the finish line. The measurement is in terms of seconds to the nearest tenth of a second from the starting signal until the subject crosses the finish line. A warning signal is given before the starting signal, and two trials with a rest in between are allowed, the better trial being recorded.

4. Flexed Arm Hang

The subject grasps a horizontal bar six feet from the floor with his palm towards the face and is assisted to pull himself to the bar so that his eyes are level with the bar. The arms are fully flexed. The subject is required to hold himself in this hanging position for as long as possible. The total period of time that the subject can maintain this exact position is determined to the nearest second. The subject must keep the bridge of his nose at the bar. One trial is allowed. The tester counts the seconds out loud. When the subject's head drops below the level of the bar, the test is terminated.

5. The 50-Yard Run

The subject assumes a starting crouch. On the starting signal, which is the drop of a flag, the runner sprints the 50-yard distance. The elapsed time from the starting signal to the passage of the runner's chest across the finish line is scored to the nearest tenth of a second. One tester may time two runners on adjacent courses with a split timer.

6. The 300-Yard Run

Starting from a racing crouch or a standing position, the subject runs straight up and around a stake marker 50 yards distance, and returns to the starting area, and completes this circuit three times totalling 300 yards. The elapsed time, from the starting signal to the passage of the runner's chest across the finish line, is scored to the nearest second.

APPENDIX J

DESCRIPTION OF HOCKEY

SKILL TESTS

LEGEND

SUBJECT	
CONE	o
FORWARD SKATING	→
JUMPING	
BACKWARD SKATING	
FINISH	F
RUNNING	

LINEAR SKATE

(FORWARD AND BACKWARDS)

PURPOSE

To measure in seconds the time it takes a subject to skate through the test course (as outlined in diagram 5).

TEST EXECUTION

From a skating start of 10', subjects skate as quickly as possible, forward and backwards through the test course.

INSTRUCTIONS

An explanation and demonstration are given. Subjects are instructed to commence skating on the second word of the command, "Ready, Go". The stop watch starts as the subject reaches to 10' line. Time is recorded at 60', 90', and 120'. A second skater is used as competition.

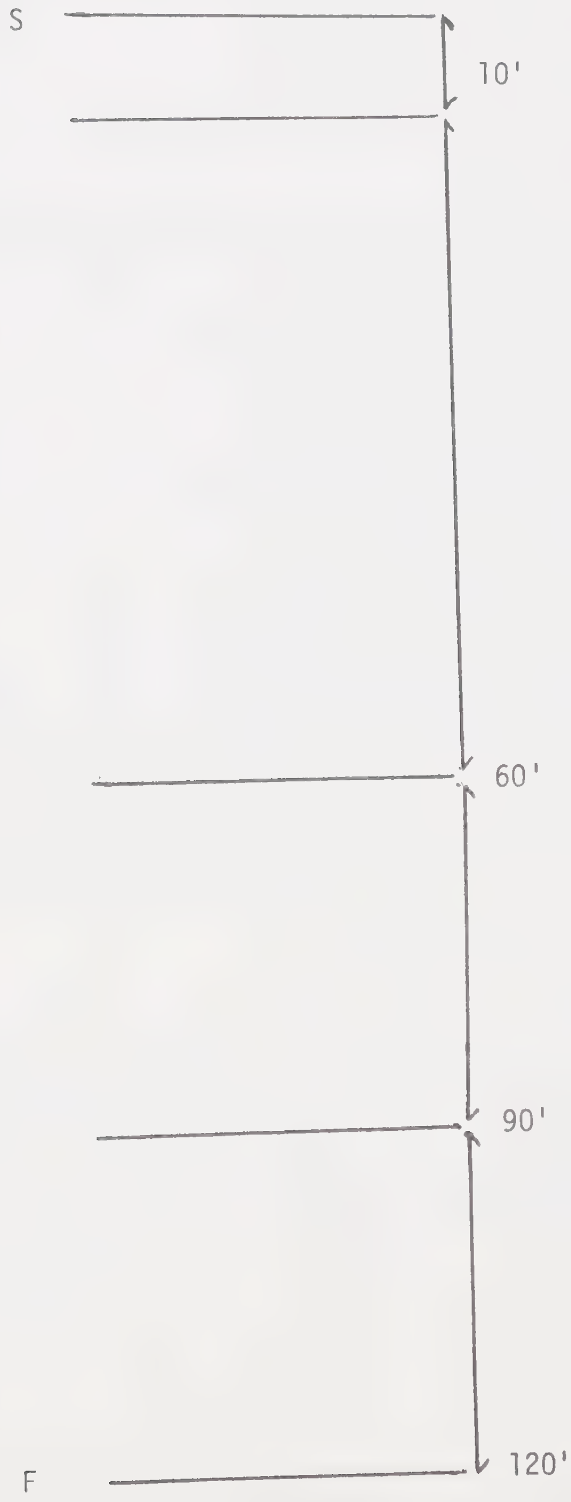
SCORING PROCEDURES

From the command "Go", the subject's time to complete the distance is recorded to the nearest tenth of a second.

DIAGRAMATIC REPRESENTATION

OF

LINEAR SKATE COURSE



MODIFIED HANSEN PUCK CONTROL

PURPOSE

To measure in seconds the time it takes a subject to skate through the test course (as outlined in diagram 1) while maintaining control of the puck.

TEST EXECUTION

From a standing start, with both skates on the blue line, a puck between his skates and also on the blue line, his body facing cone #1, the subject begins the test by kicking the puck up to his stick as he skates towards cone #1. He turns around cone #1 in a clockwise or counter-clockwise direction according to his preference, and skates toward the stick. He must carry the puck around the stick as he jumps or steps across it. He continues to the end boards, stops, skates backwards to the goal line, turns to his left and skates forward around cone #2, proceeds to cone #3, skates around it in a reverse direction to his pattern at cone #2, proceeds to cone #4, reverses the procedure at cone #3 and then proceeds to the finish line.

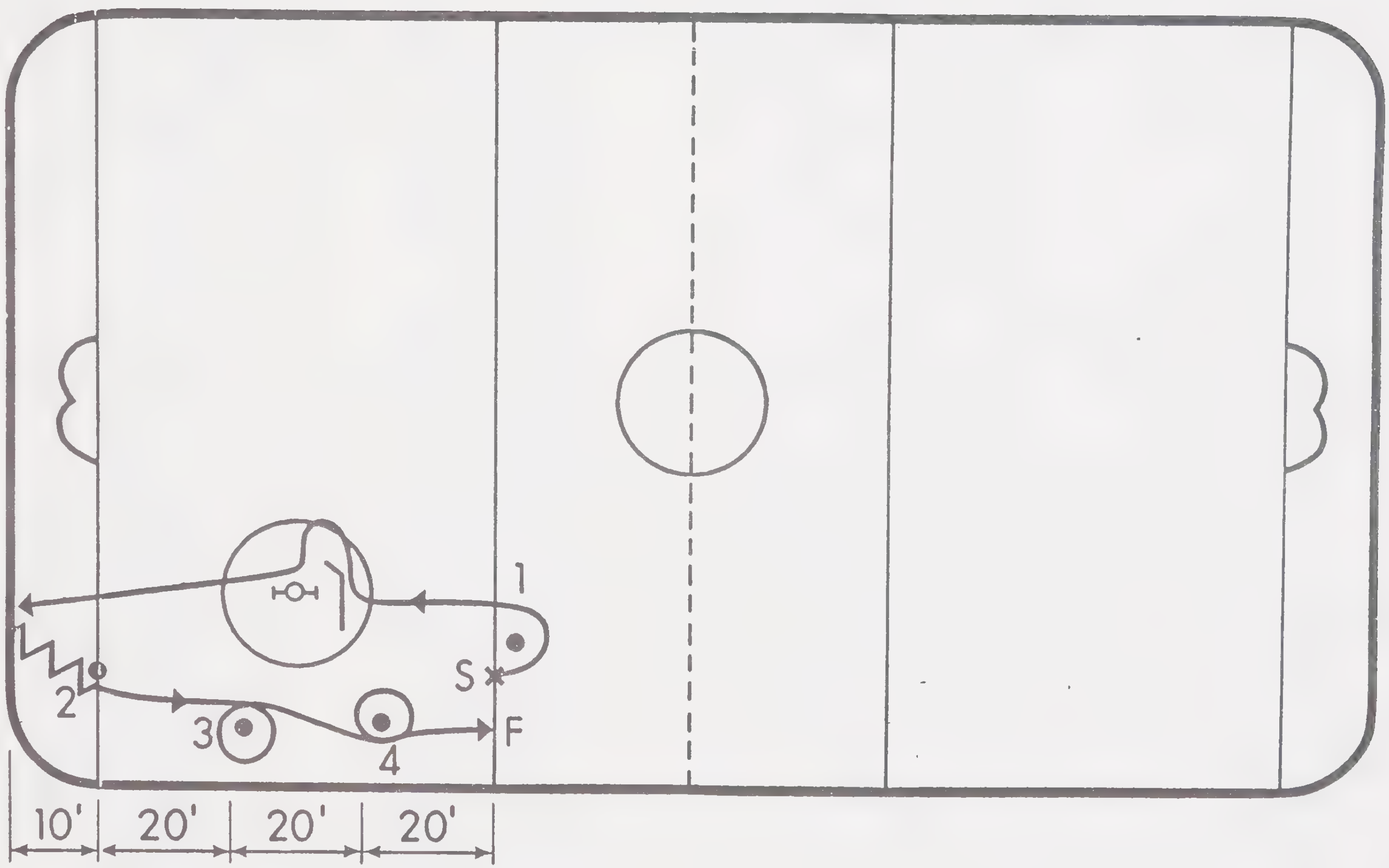
INSTRUCTIONS

Explanation and demonstration are given. Mistrials are repeated at the end of the group. Subjects are directed to skate as quickly as possible while maintaining control of the puck. The test is started by the commands "Ready, Go".

SCORING PROCEDURE

Stop watch is started on the command "Go". Watch stops as first skate crosses the finish line. Time to the nearest tenth of a second is recorded as the subject's score.

Diagramatic Representation of Modifed Hansen's Puck Control Test



MARCOTTE'S PUCK CONTROL TEST

PURPOSE

To measure in seconds the time it takes a subject to skate through the test course (as outlined in diagram 2) while maintaining control of the puck.

TEST EXECUTION

From a standing start with both skates touching the goal crease line(s) and with a puck at his stick, the subject skates to point A (face-off dot - 20'), stops, changes direction, skates to cone #1 and then weaves through cones 1, 2, 3, 4, then skates directly to the finish line (F).

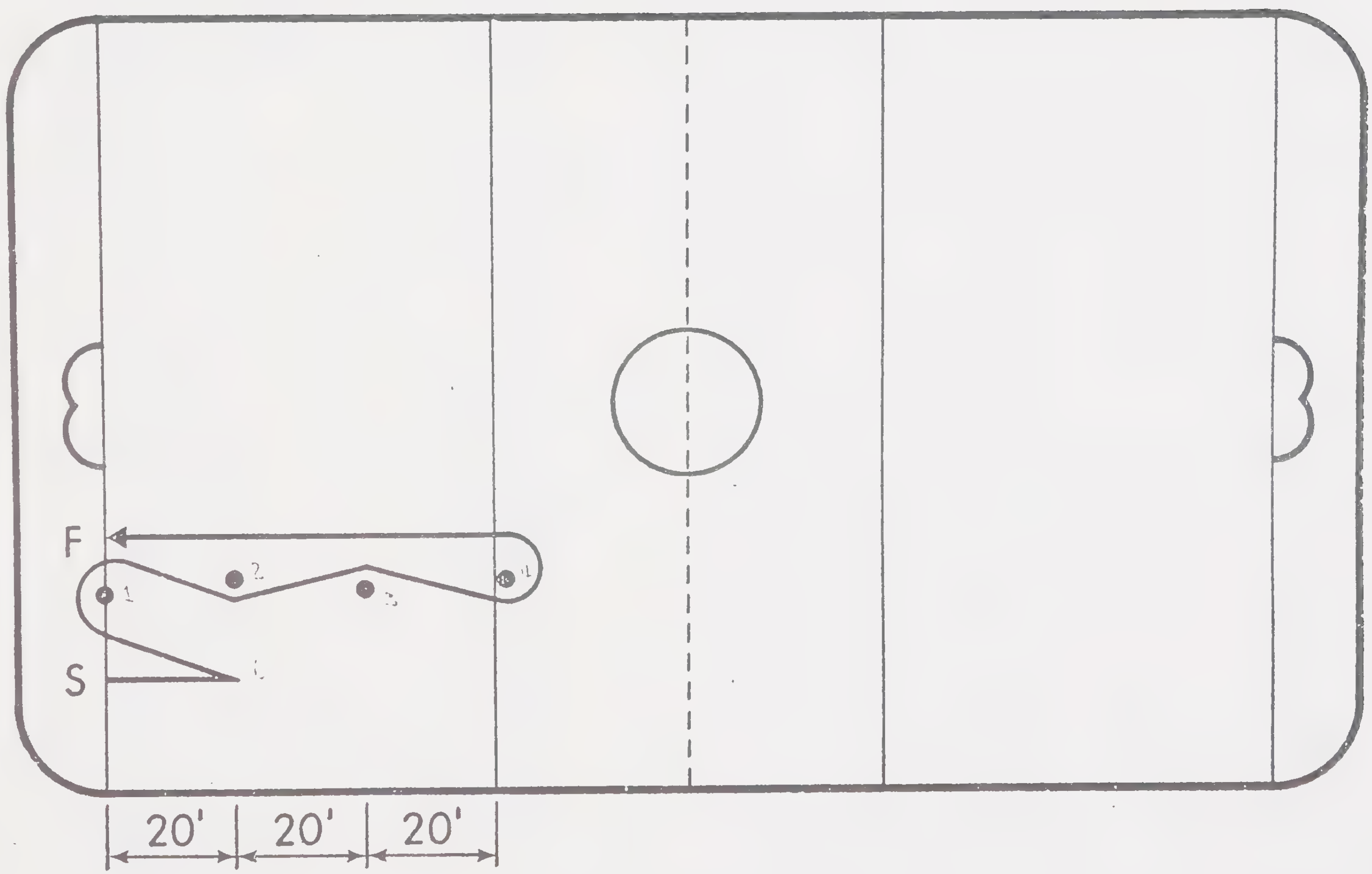
INSTRUCTIONS

Subjects are given an explanation and demonstration of the test. Mistrials are repeated at the end of the group. The stop at point A must completely be executed. The test is started with the commands, "Ready, Go".

SCORING PROCEDURE

The test administrator starts his stop-watch on the command "Go"; the watch is stopped as the subject's skate crosses the finish line. Time to the nearest tenth of a second is entered as the subject's score.

Diagramatic Representation of Marcotte's Puck Control Test



AGILITY TEST

PURPOSE

To measure in seconds the time it takes a subject to skate through the test course (as outlined in diagram 3).

TEST EXECUTION

From a standing start midway between the red and blue lines (15'), the subject skates backward to cone #1 behind the blue line, pivot turns forward, jumps over the blue line, and proceeds forward to stick lying on ice. The subject run steps the length of the hockey stick, turns and Figure 8 pattern around cones #2 and #3, touching his glove to the ice and proceeds forward to start-finish line.

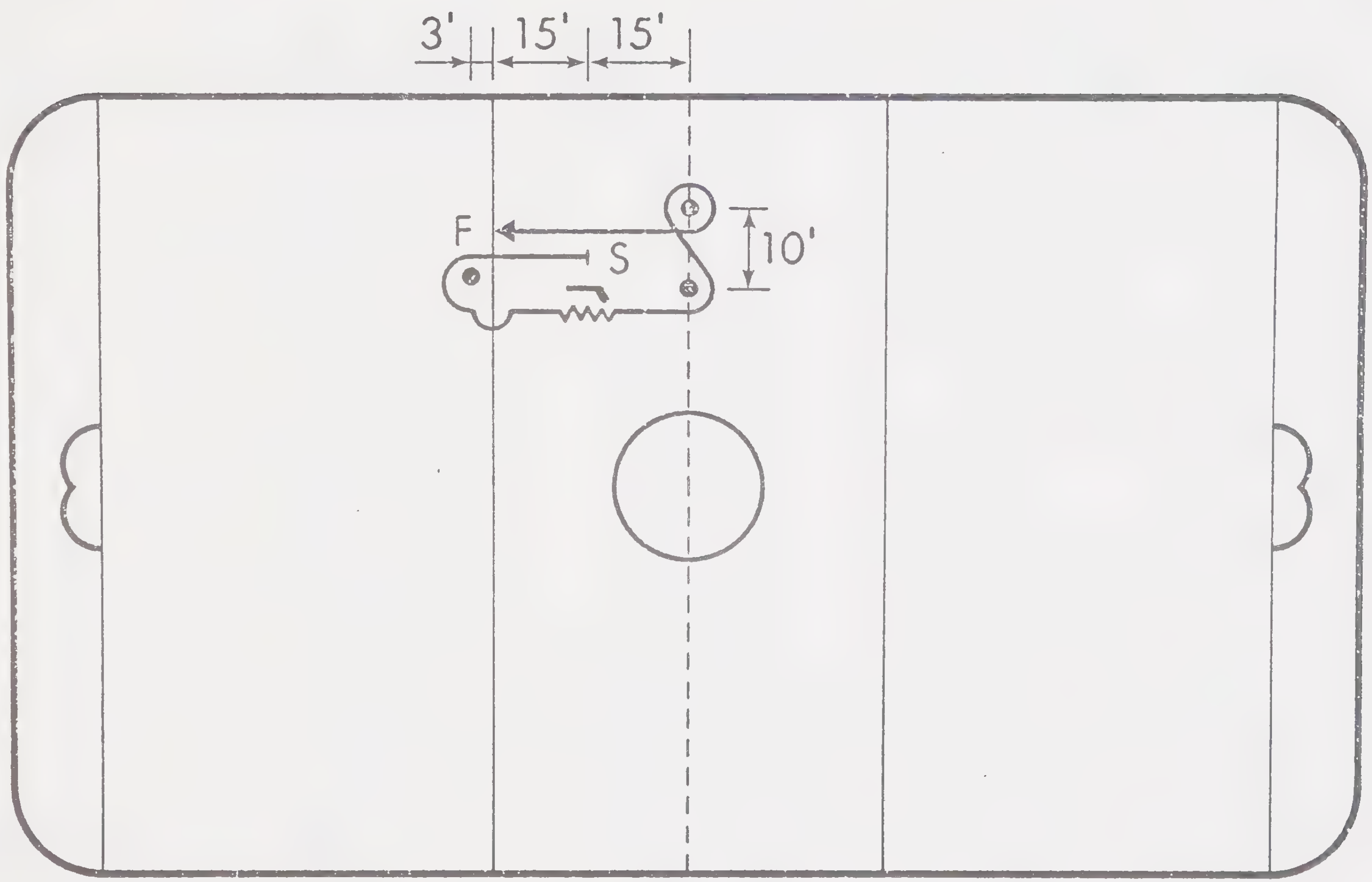
INSTRUCTIONS

An explanation and demonstration are given. Mistrials are repeated at the end of the group. The test is started on the command, "Ready, Go".

SCORING PROCEDURE

The stop-watch is started on the command, "Go" and is stopped as the subject's skate crosses the finish line. Time is recorded to the nearest tenth of a second.

Diagramatic Representation of Agility Test



BACKWARD AGILITY SKATE

PURPOSE

To measure in seconds the time it takes the subject to skate backwards through the test course (as outlined in diagram 4).

TEST EXECUTION

From a parallel standing start, facing backwards, the subject skates backwards through cones 1, 2, 3, 4, 5, and 6.

INSTRUCTIONS

An explanation and demonstration are given. Mistrials are repeated at the end of the group. Subjects are instructed to complete the pattern as quickly as possible. The test is started on the command, "Ready, Go".

SCORING PROCEDURE

The subject's time to complete the course is recorded to the nearest tenth of a second; from the command "Go", to the time he crosses the finish line.

Diagramatic Representation of Macnab and Gill's Backward Agility Skate Test